POWER PLANT ENGINEERING

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Mechanical Plant of the John Hancock Building

PLANT OF NEW BOSTON STRUCTURE BUILT TO MEET DIVERSIFIED SERVICE REQUIREMENTS. BY CHARLES L. HUBBARD

SINCE ALL ELECTRIC power used in the new home office building of the John Hancock Insurance Co., in Boston is furnished by the local public service company, the building does not contain its own power plant. In spite of this fact, however, there are in this building many mechanical features which should be of especial interest to the operating engineer. In the past, the mechanical plant of an office building has been thought of principally in terms of boilers and engines; but the modern outfit for a building of this type means much more, and includes a large amount of equipment of equal interest and importance, among which may be mentioned special systems of heating, ventilating and air-conditioning apparatus, elevators, refrigerating machinery, domestic-hot-water and drinking-water service, sanitary equipment and special automatic drainage systems for deep basements which extend below the sewage system, electrical systems for power and lighting, special low-tension systems for signals, private telephone lines, pneumatic conveyors, all of which come under the general charge of the superintendent, chief engineer, and electrician.

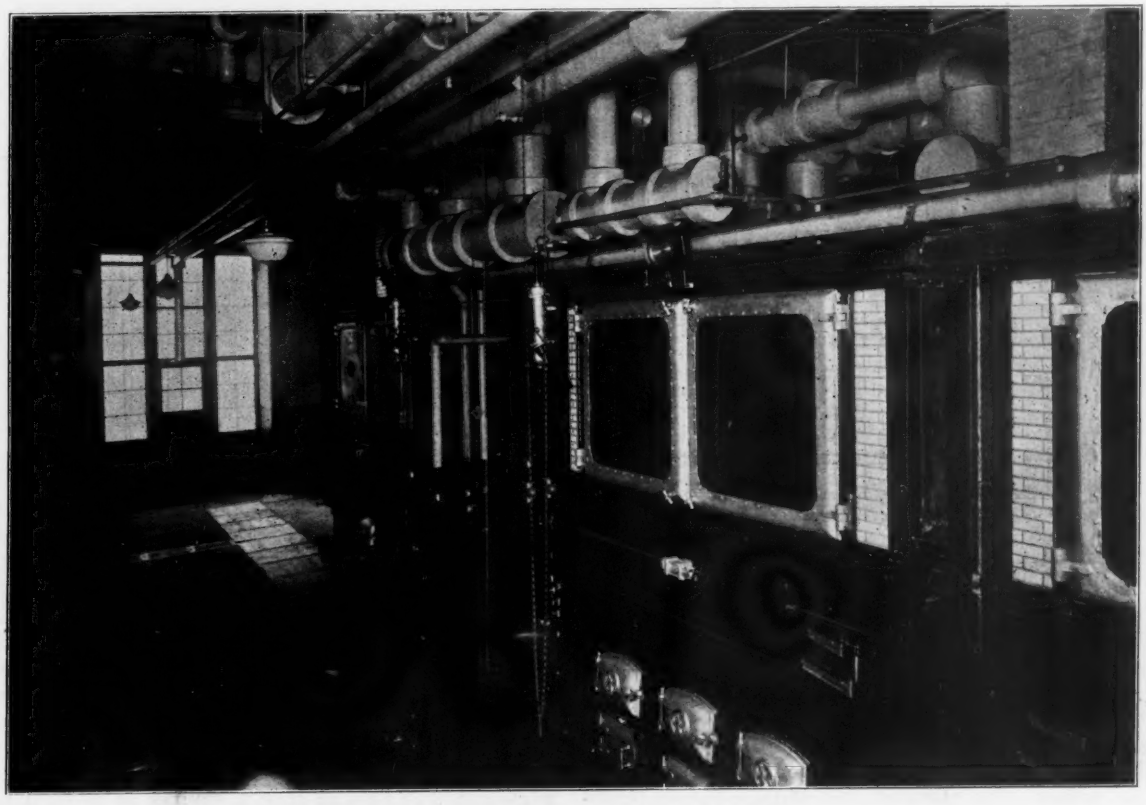


FIG. 1. VIEW SHOWING THE BOILER FRONTS

Electric power used in the John Hancock Building is purchased from the Edison Company. The building plant, therefore, is not equipped with engines and generators, but the boilers and piping are designed for high-pressure service, so that a private power plant may

be installed whenever desired with a minimum of alterations.

In other respects, it contains one of the most completely equipped mechanical plants of its kind in New England. The building has a ground area approximately 250 by 250 ft.; is six stories in height, including the basement, with a central tower 11 stories in height. Foundations and other construction have been designed with special reference to ultimately carrying the whole building up to a height of 10 stories above the street level, with accommodations for approximately 6000 employes.

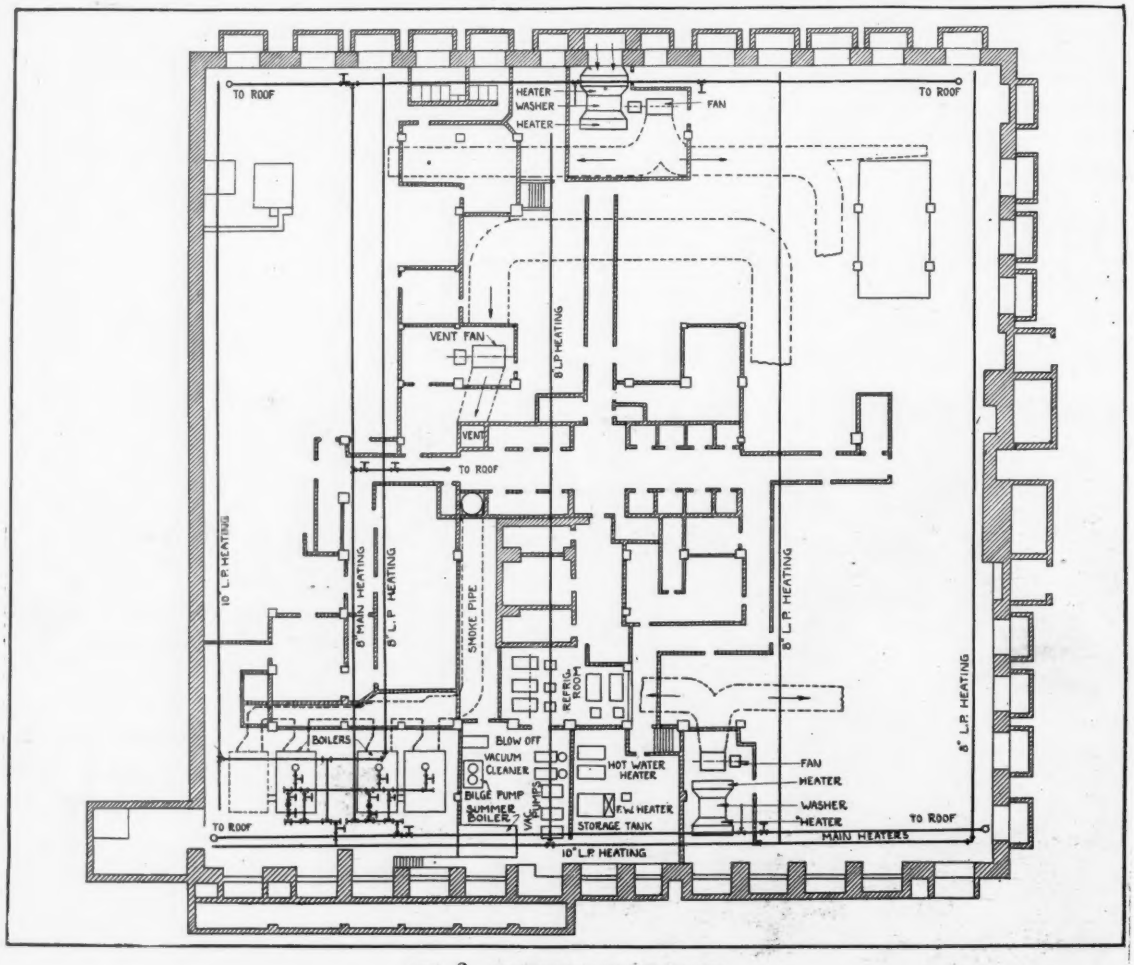


FIG. 2. BASEMENT FLOOR PLAN

One Boiler Is Fitted for Burning Oil

In Fig. 2 is shown a plan of the basement floor on which the boiler room may be noted in the lower left-hand corner. The plant consists of three Keeler, cross-drum, water-tube boilers, rated at 358 hp. each, with space reserved for the installation of a fourth unit of the same size. Two of the boilers are set in battery and are equipped for burning coal, while the third is designed for fuel oil, the special equipment being designed and installed by the Petroleum Heat and Power Co. All boilers are furnished with the usual outfit in the way of trimmings and other attachments, including mechanical soot-blowers.

At the present time a pressure of 75 to 80 lb. is carried, which is reduced for different purposes as required, about 2 lb. being carried on the direct heating system, 10 to 15 lb. on the indirect stacks at the fans, 35 to 40 lb. on the hot-water heating coils and for kitchen service, while full boiler pressure is employed for the operation of pumps and turbines.

Steam for summer use, when the heating plant is out of commission, is furnished by a Kewanee oil-burning steel boiler, rated at 50 hp. and carrying 40 lb. pressure. An interesting detail in connection with the boiler plant is the method of supporting the main smoke pipe, which is of considerable length, and therefore has more or less movement due to expansion and contraction. The method employed is shown in principle in Fig. 3, and consists in clamping lengths of 3-in. pipe to the angle-iron side bars in such a manner as to form two rails the entire length of the flue. These, in turn, rest on rolls, as shown in the drawing, thus giving free movement to care for all change in length due to expansion and contraction.

Ashes are removed from the building by a bucket, running on an overhead trolley, this being arranged to dump into a conveyor elevator, which raises them to an overhead bin, from which they are discharged through a chute into trucks at the street level.

All heating surface, both of the direct and indirect systems, is operated on the return-line vacuum principle, the main returns being connected with a header, which in turn leads to three Jennings centrifugal vacuum pumps, so arranged that any one, or all three, may be operated at any time. Under normal conditions, two units do the work easily, thus keeping a relay constantly in reserve. Two of these pumps are driven by direct-connected steam turbines, and one by an electric motor.

Each pumping unit consists of separate air and water runners upon the same shaft, the air being discharged outboard and the water into a vented receiver. The piping arrangements for this equipment are shown in detail in Figs. 4 and 5. In connection with Fig. 6, attention is called to the main gage board, which contains the following apparatus:

Clock.

Pressure gage for heating system (combined pressure and vacuum).

Pressure gage for boilers (indicating).

Pressure gage for boilers (recording).

Thermometer for feed water (recording).

Gage for city water pressure (indicating).

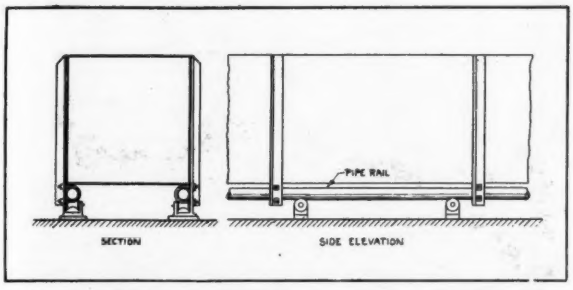


FIG. 3. DETAIL OF SUPPORT FOR BOILER SMOKE FLUE

Gage for compressed air (indicating).

Gage for steam line to kitchen (indicating).

Gage for steam line to main heaters (indicating).

Gage on steam line to kitchen (recording).

Gage on steam line to main heaters (recording).

From the receiving tank the water flows into a Yarway V-notch meter, and from here to the feed pumps which return it to the boilers. These pumps are installed in duplicate, and are the Worthington duplex, direct-acting, 10 by 6 by 10 in. in size. During the summer when the heating system is not in use, the returns from the hot-water tanks and kitchen equipment are tapped to an automatic pump and receiver, size 4½ by 2¾ by 6 in., and returned to the Kewanee boiler.

Basement Drainage

As the basement is below the level of the adjacent sewer main, it is necessary to raise all drainage by means of pumps. Three collecting chambers or sumps are provided, one for the toilets and two for all other drainage. The first of these is provided with two centrifugal pumps, driven by 5-hp. direct-connected electric motors at a speed of 1150 r.p.m. The other two tanks are each provided with two 7½-hp. electric pumps, operating at the same speed, and are so piped as to be interchangeable on the work.

Hot-Water Heating

Hot-water is heated for use in lavatories and the kitchen by means of steam coils in two 1000-gal. copper tanks, so piped as to use either high or low-pressure steam (see Fig. 6). These storage heaters may be used either separately or together as desired. In order to have hot water instantly available at the faucets it is

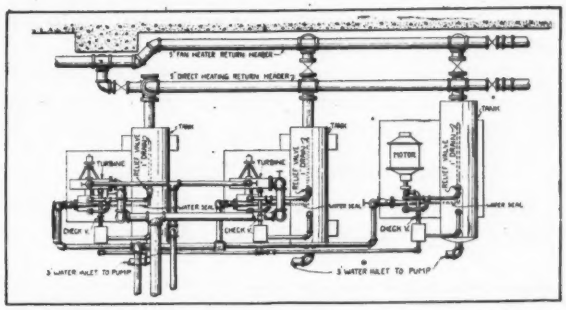


FIG. 4. PLAN OF VACUUM PUMPS AND CONNECTIONS

circulated on a loop system by means of two centrifugal pumps driven by direct-connected 2-hp. electric motors running at 1700 r.p.m. The pumps are duplicates, and one is held in reserve. The temperature of the water is automatically controlled by a special thermostat which operates the steam supply valve to the coils by means of compressed air.

Drinking Water System

Water for drinking is cooled by mechanical refrigeration and circulated through a loop system by an electrically driven triple pump. Two automatic refrigerating machines, furnished by the H. W. Johns-Manville Co., are used, each having a capacity of 2 T. of refrigeration per 24 hr. These machines are driven by belted electric motors of 5-hp. capacity.

Cold Storage Equipment

A restaurant, serving from 1800 to 2000 employes at the noon hour, is operated on the premises. In connec-

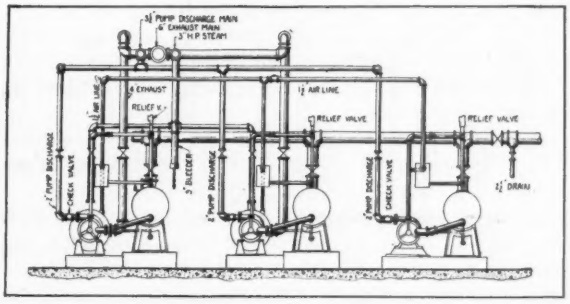


FIG. 5. ELEVATION OF VACUUM PUMPS AND CONNECTIONS

tion with this are three large cold-storage rooms, equipped with brine coils, the brine being cooled by means of three refrigerating machines of the same make and size as those used for the drinking water. These machines are motor-driven, as are also the two brine circulating pumps. In addition to the brine equipment is a tank for ice making.

A complete vacuum cleaning system is installed in the building with exhauster and separating tanks in the

basement. The exhauster is the Sturtevant centrifugal machine, driven by a 15-hp. electric motor. Two units are provided, thus furnishing a relay in case of accident or repairs.

An interesting feature of the building is the pneumatic tube system. This is the largest Lamson system ever installed, consisting of 29 sub-stations. The tubes are of extra large size, 4 by 7 in. oval, designed especially for carrying documents. An interesting feature in connection with the installation of this system was the fact that all tubes had to be bent on a 5-ft. radius, and could only be bent in one plane, which greatly increased the difficulty of placing them.

Electric Power and Switchboard

Electricity for power and lighting purposes is purchased from the Edison Electric Illuminating Co., of Boston. The possibility of any interruption of service is guarded against by providing two sources of supply. One panel on the main switchboard is connected with the adjacent street service, and three more have direct connection with the Stuart Street sub-station, which is near-by.

A recording watt-meter gives and records the total load at all hours of the day, while individual house meters are provided for each group of risers.

Distribution is effected through a 3-wire, 115-v. system. An interesting feature in connection with the switchboard is a system of signals on the circuit breakers to the different lines. These consist of three lights, one white, one green, and one red. When the red light only, shows, the line is alive and in working order. When the green and white show, there is a short-circuit on the line, calling for attention. When green, only, shows, the current is turned off from the circuit for purposes of repair.

Elevators

There are six Otis passenger elevators in use at the present time, and space is provided for six more when the building is completed. The detail of especial interest in this installation is the micrometer device for automatically bringing the car to a stop at the exact floor level on each landing.

If the hand switch is thrown off when the car is within 8 or 10 in. of the floor level, the automatic device will bring it to the exact position desired. Each elevator is equipped with a 35-hp. motor for carrying the load, and a 3½-hp. motor for operating the micrometer. It is interesting to note that this was the first direct-current application of this device in New England. All elevator doors are operated by compressed air furnished by duplicate electrically-driven compressors of the geared type, driven by 7½-hp. motors running at a speed of 1150 r.p.m. Lubrication is provided for by passing the air under pressure through a chamber filled with an oil vapor which rises from the liquid in the bottom of the chamber. A view in the elevator machine room in the tower is shown in Fig. 7. There is also a private A B C elevator running from the finance department to the vault and bond room, and a freight elevator of the same make, both electrically operated.

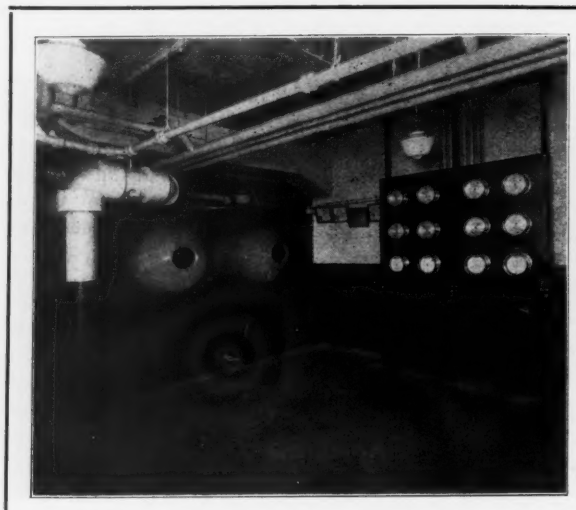


FIG. 6. HOT WATER BOILERS AND MAIN GAGE BOARD

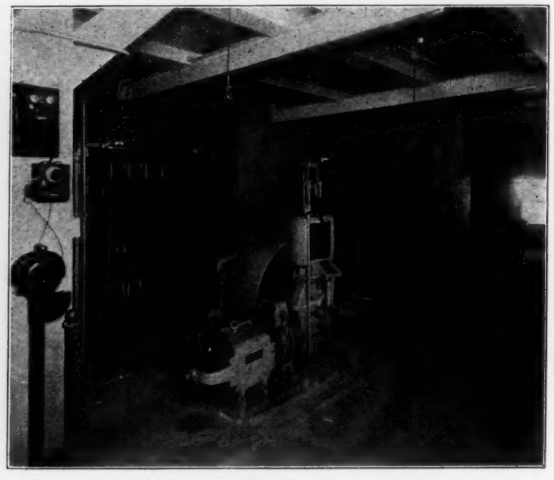


FIG. 7. VIEW OF ELEVATOR MACHINERY

Telephone and Low-Tension Service

Telephone equipment consists of two systems, one for outside service, including 140 of the New England Telephone Co.'s instruments, and an inside service of about 350 automatic outfits, made and installed by the Automatic Telephone Co. of Chicago. These are assembled in three groups, of 100 each, and 20 conversations can be carried on at one time on each group. The storage battery used with this system carries from 48 to 50 v., and is charged by a special motor-generator.

The low-tension or signal system is operated from a master clock in the superintendent's office, this being the largest ever installed by the E. Howard Clock Co. This, through electrical connection, controls the program bells in the different departments, and records the watchman's signals and employes' record sheets. The clerical force is governed entirely by the program bells, but the maintenance force, and employes of the printing plant are required to make use of time clocks and automatic recording devices.

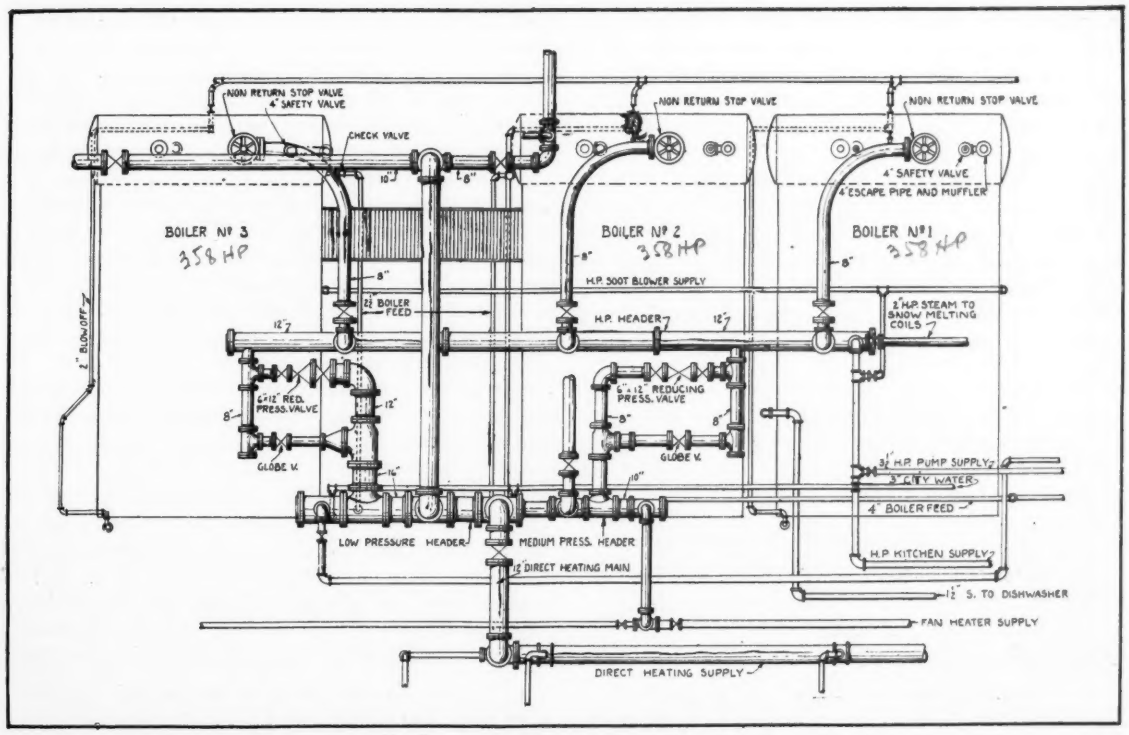


FIG. 8. PLAN OF BOILER CONNECTIONS

In addition to the clock service there is an extensive system of annunciators for calling messengers, stenographers, etc., and also a separate connection with the elevator service.

Heating and Ventilating System

Of the equipment installed in the John Hancock Building, the part in which the readers of this magazine will be most interested is the heating system. The building is heated throughout by direct radiation, this system being entirely independent of the ventilation. The present installation contains 42,500 sq. ft. of direct radiating surface, exclusive of piping, and the mains and risers are proportioned for 36,000 sq. ft. of additional surface upon completion of the building.

The indirect surface, used in connection with the fans, totals about 14,300 sq. ft. The direct radiation, for the most part, is located beneath the windows, and both the direct and indirect systems are automatically controlled by the Johnson pneumatic system of temperature regulation. The air compressor for this work is electrically driven, and there is a cross-connection between this system and the one operating the elevator doors, for use in case of emergency.

In order to reduce the resistance to air flow, and also limit the size of vertical flues, the ventilation system has been divided into two parts, the first, including the three lower floors and the second the three upper ones. The lower section is provided with 70,000 cu. ft. of air per minute by two centrifugal, multi-vane fans, located in the basement as shown in Fig. 2. Each fan is driven by a direct-connected 15-hp. electric motor, running at 250 r.p.m. The air delivered by each fan is warmed and purified before delivery to the distributing ducts, by passing first through a tempering heater, then a Sturtevant air washer, and finally, a reheater, for bringing it to the desired temperature of 70 deg. F. The heaters are made up of "Vento" cast-iron sections, grouped and valved for proper regulation. The air washer not only removes all dust from the incoming air, but is designed and equipped for the automatic regulation of humidity, within certain limits. The principle employed in this washer for humidity control is that of varying the temperature of the spray water by means of an inside coil located in the spray chamber.

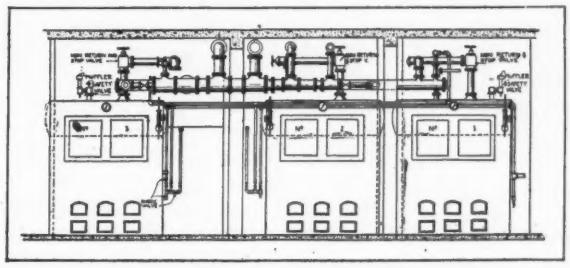


FIG. 9. ELEVATION OF BOILER CONNECTIONS

Air is exhausted from the lower portion of the building by the use of a fan of the same type as for the supply, and having a capacity of 70,000 cu. ft. per min. at a speed of 185 r.p.m. This fan requires a 20-hp. motor. Recirculation of air within the building, for quick warming, is arranged for by closing communication with the outside, both at the supply and exhaust fans, and opening doors in such a way that the discharge from the exhaust fan passes through corridor ways to the cold-air rooms back of the heaters and washers. All horizontal ducts for the distribution of air between the fans and vertical uptake and downtake flues are carried at the basement ceiling, but are not shown in the drawing. The

upper part of the building is ventilated by four sets of equipment, each consisting of supply and exhaust fans, and heater. These are located in pent houses on the roof of the building, and the air is blown downward. As the air in this case is taken from a high elevation, no washers are used.

Each fan, both for supply and exhaust, has a capacity of 12,000 cu. ft. of air per min., and is driven by a direct connected 3-hp. motor, those for the supply fans running at 210 r.p.m. and for the exhaust at 185 r.p.m. A fifth ventilating equipment, located upon the roof, and of the same capacity as the other four, is used in connection with a large assembly hall upon the upper floor. The roof heaters are of the same type as those in the basement and have a total of 6800 sq. ft. of surface.

Special exhaust fans for the kitchen, grill room, and toilets, have a total capacity of about 8600 cu. ft. of air per min. All combined supply and discharge ventilating equipments upon the roof have damper arrangements so that the air from the discharge fan may be delivered directly to the supply fan through the heater, thus recirculating the air within the building when desired. The same is also true of the assembly hall equipment.

Piping

All steam and return piping is of standard weight. The joints in the main header are welded, and the Van Stone joint is made use of in the heavy high-pressure piping over the boilers. The general layout of the boiler-room piping is shown in Figs. 8 and 9. The leads from the three boilers connect with a 12-in. high-pressure header, from which close connection is made, through reducing valves with low-pressure and medium-pressure headers, as shown. The first of these is 16 in. in diameter, and from it lead two 12 in. mains for supplying the direct radiation. The medium-pressure header is 10 in. in diameter, and supplies the seven main heaters used in connection with the various ventilating fans. The general arrangement of the different mains is shown approximately upon the basement plan, Fig. 2. High-pressure lines for the pumps and turbines are taken directly from the high-pressure header. As previously stated, all high-pressure piping is designed especially for the possible future installation of engines or turbines.

All valves 2 in. and smaller have brass bodies, and larger sizes cast-iron. Outside screw and yoke valves are used for the larger sizes on the high-pressure piping. There is a non-return valve on each boiler. All high-pressure work is covered with magnesia insulation, and low-pressure pipes with four-ply air-cell asbestos. The boiler settings are finished with an elastic cement wash.

Boiler Plant Operation with Fuel Oil

Features of Fuel Oil Burning in Its Relation to Installation, Operation and Maintenance. By Kingsley L. Martin*

EFFICIENT burning of fuel oil is based upon fine atomization just prior to the time when it comes into contact with the air for combustion and a complete and thorough mixing of the finely divided oil and air. Ideal conditions would prevail were it possible in practice to burn the oil with just the right amount of air for complete combustion; this, however, cannot be done and the problem of air supply then becomes that of reducing to a minimum the excess air admitted to the furnace.

Fineness of atomization is dependent upon four factors: (1) the design of the atomizer; (2) the proper straining of the oil; (3) heating of the oil to the proper temperature; and (4) care of the operators to maintain the atomizers in, as far as possible, their original condition.

Thorough straining of the oil before it reaches the burner is essential, otherwise the passageways through the burner may become clogged, thereby destroying the uniformity of atomization and reducing the capacity. The fine gritty substances carried by the oil will also cause considerable wear of orifices and nozzles within the burner or atomizer. It is the general practice to fit a basket type strainer on the suction line, the mesh of the wire gage to be rather coarse, probably no finer than 28 mesh is recommended. This suction line strainer will give ample protection to the pumps without causing excessive suction lift. Additional strainers of a finer mesh may be located after the pump as a further protection to the burners.

Fuel oil is heated for the purpose of reducing the viscosity or in other words, increasing fluidity. It may often be necessary to heat the oil at the point of storage so that it can be handled by the pumps. Further heating before applying to the burners may be necessary as an aid to fineness of atomization. As a general rule, it may be stated that the thinner the oil the finer will be the atomization produced and conversely the greater the viscosity the more difficult it becomes for the atomizers to break the oil into particles fine enough for its intimate mixture with the necessary air for combustion.

Curves given herewith show graphically the effect of heating upon the viscosity of fuel oils. It will be observed that for those oils having a gravity of 16 deg. Baumé (specific gravity 0.9589) and above very little reduction in viscosity is gained by heating above 180 deg. F. In the case of the more viscous oils it is neither desirable nor practicable to heat the oil above the temperature that will give a viscosity between 8 and 10 deg. Engler, as to do so would require heating the oil to a temperature high above the flash point, which is a dangerous expedient unless extreme care is taken to guard against leaks in the oil lines. As previously stated, a lower viscosity will afford a finer atomization and consequently more rapid and efficient combustion, which, incidentally, will permit of a greater rate of combustion per cubic foot of furnace volume per hour. In addition to the objection cited to the heating of a very viscous oil to excessive temperatures may be added the space required for heaters of sufficient capacity, and also the danger of breaking down the oil, causing it to clog up the heaters and oil lines and to carbonize the atomizer.

Aids Toward Furnace Efficiency

Intelligent use of the gas analysis apparatus is the most positive and direct aid in obtaining maximum

* President, The Engineer Co.

furnace efficiency. A study of the appearance of the furnace in conjunction with the appearance of the gases emitted from the stack form a very practical basis upon which to judge the results of combustion. If the flame is an incandescent white and the furnace walls are clearly discernible through it, the operator may feel certain that he is running with an excess of air. As the percentage of air is reduced, the color of the flame at the rear of the furnace becomes a pale yellow, then yellowish orange and finally orange red. In general, with an efficient installation operating with a minimum of excess air, the ends of the flame farthest from the burner will be a yellowish orange or golden shade. The gases of combustion will be colorless and the seams in the brickwork barely visible across the width of the furnace. At very high rates of combustion when the flame completely fills the furnace, the very high furnace temperatures preclude the presence of these temperature colors. An incandescent and dazzling white will indicate excess air, but a reduction in this excess is only indicated in the furnace by a softening of the intensity of the white flame. A perfectly clear stack is deceiving. It may mean only a small amount of excess air or it may mean as much as 300 per cent excess. A clear stack is ideal when the gas analysis at the same time shows high CO_2, very low O_2 and no CO, for example 14.7 per cent CO_2, 1.8 per cent O_2 and 0 per cent CO. Under the usual operating conditions, it is good practice to require the fireroom personnel to reduce the supply of air until a very light brown haze is emitted from the stack, since a trace of light brown smoke emitted from the stack in a uniform manner generally indicates 10 to 15 per cent excess air, while to remove all traces of smoke will, in most cases, require an excess of 50 per cent or above.

It is well to remember that the presence of smoke does not always mean insufficient air or high CO. An inefficient installation, poor atomization, poor mixture of air and oil, unconsumed oil striking cooling surfaces, poorly designed furnaces, etc., frequently cause smoke when air supplied for combustion may be far in excess of that required. Defects of this nature must be eliminated before a proper study of efficient oil and air regulation can be attempted. Air leaks in the setting must also be stopped.

Furnace Design

Shape, size and materials of construction of the boiler furnace have a very decided influence on both the furnace efficiency and the rate of combustion when oil is used as the fuel. The ideal furnace would have the following characteristics:

(a) Sufficient furnace volume for total oil burned at designed rate of combustion.

(b) The maximum of refractory surface to assist in maintaining a high furnace temperature.

(c) Increase of cross-sectional area of the furnace with the expansion of the gases.

(d) Minimum area of cooling surfaces close to the flame, which tend to reduce the furnace temperature.

(e) Walls and tubes sufficiently remote from atomizers to permit of complete combustion of oil before coming in contact with them.

(f) A minimum of infiltration of air except through the air controlling registers provided for the purpose.

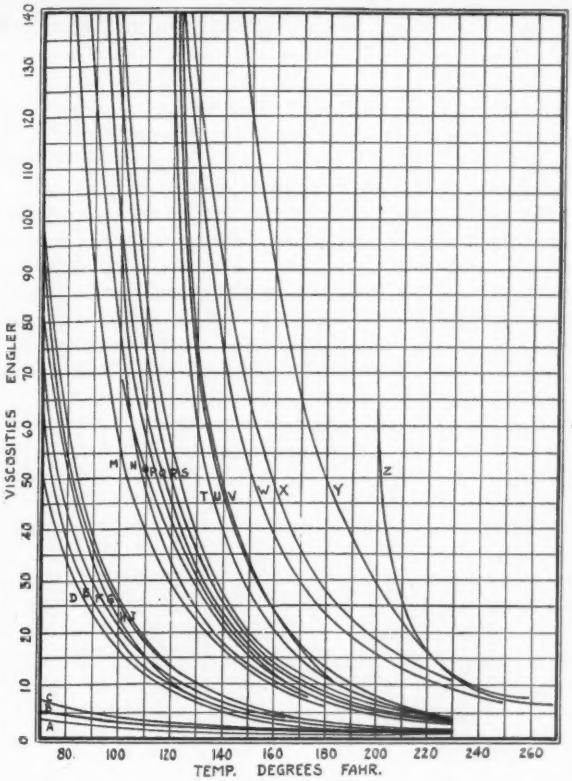


FIG. 1. TEMPERATURE VISCOSITY CURVES OF VARIOUS GRADES OF OILS

A. "Standard" Mexican gas oil, 34.3 deg. Baumé, 151 deg. F. flash.

B. Gulf Refining Co.'s Navy standard oil, U. S. S. Roe, 28.7 deg. Baumé, 182 deg. F. flash.

C. Camden Chemical Co., by-product of coal tar, 6.0 deg. Baumé, 108 deg. F. flash.

D. "Standard Star," California, 23.9 deg. Baumé, 180 deg. F. flash.

G. "Standard" Lima, Ohio, crude, 30.4 deg. Baumé, 149 deg. F. flash.

E. "Standard" Indiana, 29.6 deg. Baumé, 144 deg. F. flash.

H. Gulf Refining Co., Navy standard, 29.25 deg. Baumé, 170 deg. F. flash.

F. "Standard" Illinois, 27.2 deg. Baumé, 146 deg. F. flash.

J. Gulf Refining Co., navy yard oil, U. S. S. Perkins, 27.5 deg. Baumé, 180 deg. F. flash.

M. Texas Co.'s Reduced Mexican crude, 17.3 deg. Baumé, 162 deg. F. flash.

N. "Standard" Mexican crude, 17 deg. Baumé, 145 deg. F. flash, lot No. 1).

O. Sample No. 2, Anglo-Mexican Petroleum Products Co., 16.2 deg. Baumé, 238 deg. F. flash.

P. "Gaviota Refinery" Associated Oil Co., California, 17.1 deg. Baumé, 230 deg. F. flash.

Q. Sample No. 3, Anglo-Mexican Petroleum Products Co., 17.3 deg. Baumé, 164 deg. F. flash.

R. Texas Co.'s Mexican crude, 17.3 Baumé, 126 deg. F. flash.

S. "Standard" Mexican crude, 15.4 deg Baumé, 202 deg. F. flash (lot No. 2).

T. "No. 25," Union Oil Co., Bakersville, Calif., 13.2 Baumé, 262 deg. F. flash.

U. "No. 102," Union Oil Co., Bakersville, Calif., 12.9 Baumé, 280 deg. F. flash.

V. "No. 18," Union Oil Co., Bakersville, Calif., 12.9 Baumé, 285 deg. F. flash.

W. "Toltec, or Panuco oil," Inter Ocean Oil Co., New York, 12 deg. Baumé, 124 deg. F. flash.

X. "Toltec fuel oil," Inter Ocean Oil Co., New York, 11.7 deg. Baumé, 220 deg. F. flash.

Y. "High flash heavy crude," Inter Ocean Oil Co., 10.86 Baumé, 180 deg. F. flash.

(g) Exit from furnace of incandescent gases of completed combustion at a maximum distance from the atomizers.

These are matters that affect design and are not within the control of the operating engineer, but a knowledge of them helps to an understanding of the principles of efficient combustion.

Prior to lighting fires for the first time after installation the operator should know that the entire oil system is clean and free from dirt, waste, red lead, etc. He should inspect and clean all strainers, this should also be done frequently while running. If the oil is very cold and viscous and the pumps have difficulty in getting a suction it may be necessary to use the heating coils provided in the storage tanks. Air chambers on the pumps should be drained out and recharged with compressed air. To insure that the furnace is free of explosive gases, it should be standard practice to ventilate by opening all air registers and also the boiler damper. An operator should not attempt to light a burner from red hot furnace walls. A suiable lighting torch may be made by securing a few loose turns of asbestos wick on the end of a rigid wire rod about 3 ft. long and soaking it with kerosene. If the plant must be started without steam but electric current is available, a small motor driven pump and tank of light oil (26 deg. Baumé or above) should be separately piped up to a mechanical burner, as soon as steam is obtained the regular systems may be warmed up and put into operation.

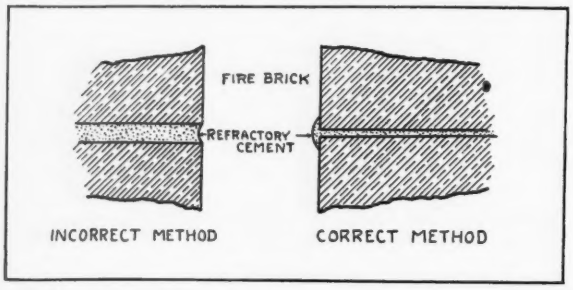


FIG. 2 INCORRECT AND CORRECT METHOD OF LAYING UP FIRE BRICK

At times a pulsating effect will be noticed in the furnace; this may be stopped by changing the draft shutters, particularly those near the burner. Pulsations may be due to rapid fluctuations in oil pressure, or when a much larger quantity of oil is being burned in one burner than in another in the same furnace, balancing the rate of fuel burning between burners will stop the pulsations.

Oil pressure does not enter into the problems of burning different oils, the question is purely a matter of ascertaining the temperature requisite in the case of each grade of oil to obtain the proper viscosity. When this viscosity is maintained the oil pressure may be the same for every grade of oil used. It must be remembered that an increase in the quantity of oil used will require a corresponding increase in draft and in the steam for atomization; both, however, should be kept as low as possible.

When it is desired to cut out a boiler, close the oil valves to the atomizers one by one, at the same time closing the air registers and slow down the oil service pump a corresponding amount. Then shut off the steam to the oil heater to prevent excessive heating of the oil as the flow is reduced. For emergency purposes, a master oil valve should be provided, the closing of which will cut off all the burners for one boiler.

When all burners have been extinguished, all air registers and other openings to the furnace should be closed to prevent cold air from rushing into the furnace for this will cause serious damage to the furnace lining and may cause warpage in straight tube boilers. The water should then be brought up to three-fourths of a glass. After hard steaming, it may be necessary to have the auxiliary stop partially opened for a while because the intense heat of the brickwork may continue to generate steam. When cutting out a boiler, both the burners and piping should be drained of all oil and blown out with steam or air; the latter is preferable because it will not have moisture in the lines, which may give trouble when starting up again.

High grade refractory material is required for the lining of a boiler furnace to assist in maintaining a high furnace temperature and thereby accelerate the rate of combustion and consequently aid in producing complete and efficient combustion. The life of the furnace refractory lining is influenced by (1) the high sustained furnace temperature; (2) rapid changes in temperature; (3) vibration or panting of the boiler. The first can only be offset by using the very best grades of high refractory brick. Rapid changes in temperature can be reduced to a minimum by intelligent operation on the part of the operator. The brickwork in boilers will be injured by too rapid warming up or by cooling off a furnace too rapidly. The damper and registers should not be left open or partially open, but close up the boiler as tight as possible and let the furnace cool down slowly. Emergencies may arise which require that these precautions be ignored, and although the brickwork will probably stand the abuse, its life will be shortened, and if such practice is continued it will soon bring on furnace troubles.

Furnace floor construction built up as follows will be found to give excellent service. Lay two courses of insulating brick, then lay the first course of fire brick, dry, break joints between adjacent rows and allow about 1/16 in. clearance between brick. Do not use mortar. Rake or sweep back and forth a quantity of dry refractory cement on top of the course just laid until the cracks between the bricks are filled, then spread the remainder over the top of the brick to a depth of about ⅛ in. Next lay the second course of fire brick in the same manner, taking care to break joints with the lower course. Over this sweep more refractory cement until the cracks or seams between bricks are filled. Smooth the remainder out over the face of the brick to a thickness of about one-eighth to one-fourth inch. The reason for the clearance between brick is to allow for expansion and contraction of the brick. In time the brick takes a permanent set and the dry cement vitrifies sufficiently to bake into a hard layer, but it does not fuse enough to flow.

Experiments indicate that refractory cement used as a mortar or binder between the bricks should under no conditions fuse at maximum furnace temperatures, but should set or bake hard and bind the brick together.

It should not show any material tendency to flux and run out of the corners or seams between the brick. This fluxing action on the part of some prepared cements and mixtures containing silicate of soda causes a glaze to form over the surface and seams of the brick. At first, an inspection of the furnace when cold gives the impression that a hard shiny glaze is to be desired. When the furnace is hot, this hard glaze does not exist, but in its stead the walls are coated with a jellylike flux from the mortar, that runs out of the seams and from the surface wash of the same material. This gradually flows, fluxing the surface of the brick and finally fills up the furnace bottom. The seams between bricks become exposed to a depth of one-half to one inch and deep fissures are frequently cut in the face of the brick, necessitating patching up at every opportunity. This flux collecting on furnace bottom will float the brick, and upon cooling will cause serious cracking and bulging.

Much care should be taken in laying up the furnace walls and in bonding the bricks. The work should be under constant, experienced and intelligent supervision. Brickwork should be laid up evenly and smoothly; make the seams between brick as small as possible, not over ⅛ in. The natural tendency is to use too stiff a mortar. A good rule to follow is to thin the mortar with water until when two bricks are cemented together and the top one is quickly raised, the lower one will be started but not completely lifted. Trowel the mortar over the entire surface of the brick to a thickness of about ¼ in., lay the next brick, and by pressing down with the hands squeeze out as much of the mortar as possible. Gentle tapping with a light wooden maul will further reduce the width of the seam.

Excess cement which protrudes from the joints should not be smoothed off to make a flush wall, but should be spread back and beaded over the joint so that the edge of the brick will be protected from direct impact of the flame. When properly beaded out the cement will weld with the bricks and form a perfect protection to edges and corners where they are most liable to crumble away. The walls should be allowed to set for a few hours and then should be hardened by lighting fires with one atomizer to give a gentle heat.

After the walls are thoroughly dried out a thin refractory wash should be applied, merely to take the erosive action of the flames and gases of combustion which impinge against the surface. This wash must be of such character as to form a smooth nonglazing surface that will, after continued use, become hard and flintlike, and serve as a real protection to the edges and exposed surface of the brick. The same cement which is used as a mortar should also be used for the wash by adding to it a greater quantity of water, so as to form a thin mixture, which may be applied with a brush.

Remote Control of High Pressure Steam Lines*

PROTECTION AND OPERATION OF STEAM LINES BECOMES MORE VITAL AS STEAM PRESSURES AND TEMPERATURES ARE INCREASED. BY PETER PAYNE DEAN

STEAM pressures as high as 350 lb. per sq. in. with 700 deg. F. total heat are now frequently encountered, and no doubt 500 lb. will soon be standard practice. Under such pressures every piece of valve, piping, and fitting metal will be subjected to an excessive strain, which, when coupled with high temperature, may produce results akin to metal fatigue, about which we have very little knowledge and even less experience. Further, no safe standard has been universally adopted for 500-lb. steam fittings, bolts, flanges, expansion loops, etc., but this will very probably come after more exhaustive time tests.

Protection of human life, however, should be the first consideration, and after that, continuity of plant operation and protection of property; and surely all will agree that protection beyond that found in the average plant is necessary. We never think of asking an operator to trip an oil switch manually, which is done from the central switchboard; therefore, why ask him to mount a boiler or scramble through dark galleries to shut off a steam break when it may be done from a safe point by merely turning a switch? We can only make every attempt to prevent failure by careful design, and then provide, as a matter of precaution, the best possible safeguard if it does happen.

LOCATION OF MASTER VALVES

Master valves should be those nearest the boiler, and either the automatic stop checks or gate valves in the boiler lead. Valves at this point protect the complete piping system and would not be affected by mechanical movement of a broken line, which would possibly throw excessive strain on a gate valve, causing it to jam. Automatic stop-check and boiler-lead gate valves are seldom above 10 in. in diameter and without doubt can be closed in from 15 to 30 sec., so that any or all of the boilers may be cut out at will.

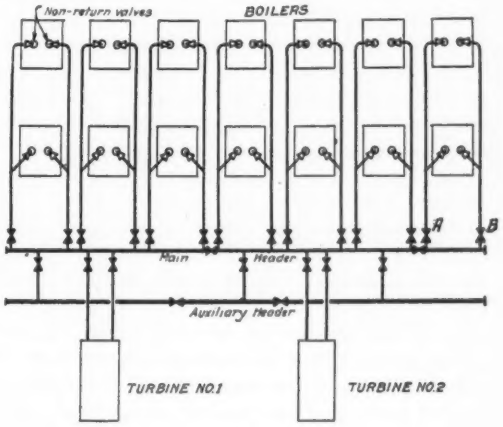


FIG. 1. BOILER AND PIPING LAYOUT FOR COLFAX STATION

Unless all the boilers are isolated there would be a reverse flow from the header back through the break, so that a master valve is also necessary in the boiler lead at the header, which in any event is usually in-

*Abstracted from paper presented at the Spring Meeting of the American Society of Mechanical Engineers, Montreal, Canada, May, 1923.

respect to line protection, being directly at the superincluded. Closing both the boiler-lead valve and this last-mentioned valve completely isolates one boiler.

The principal argument against emergency closing off of the boilers is that the plant would be completely shut down. However, if a bad break occurs its location cannot be determined until almost the entire steam supply is stopped. As soon as the break is located, the sectionalizing valves may be brought into play and the boilers quickly brought back on the line.

Even though large header valves can be closed from a distance, nevertheless the quick and safe way is to shut off the boilers in sections until the break is stopped. Incidentally, with any remote-closing scheme the boiler safety valves should be piped to a header and blown to

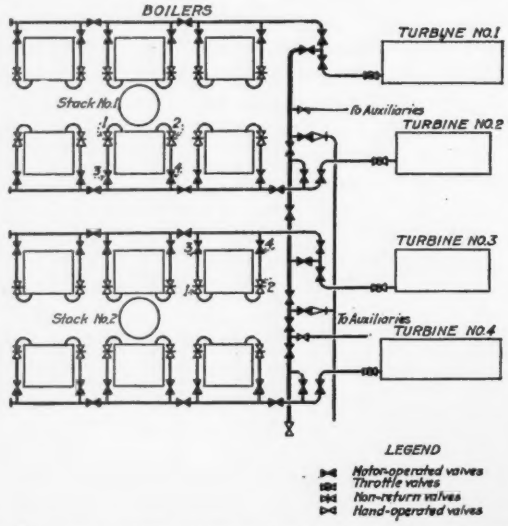


FIG. 2. HELL GATE STATION BOILER AND PIPING LAYOUT

atmosphere, as in the event of a boiler shutdown they would all blow together. Some arrangement also of an auxiliary header should be worked out to supply the boiler-feed pumps, as well as a scheme for shutting down the draft fans. Power-operated header valves of large diameter may be depended upon to stop a very bad fitting blow or gasket leak, so for this reason and also for convenience of operation they should be provided with remote control.

To close an 18-in. high-pressure gate valve requires two men for a period of at least 15 min., including transit to and from the valve, not to mention the physical effort necessary and the danger of penetrating a steam-laden alley with very uncertain conditions under foot. For years engineers have applied power operation to sash monitors, ash gates, dampers, and other auxiliaries, but seem to have entirely overlooked the poor old steel sentinel that stands guard over the main artery.

Figure 1 shows a typical existing boiler and piping layout in which electrically operated valves are employed. Complete isolation of one boiler from the line may be made by closing any pair of valves, A, B, either singly or from one switch, but this of course leaves the boiler-lead lines unprotected. Further protection may be accomplished by electrically operating the non-return valves shown and closing them together with valves A, B, in order to prevent reverse flow from the header. Figure 2 shows a similar system wherein the boiler-lead valves may be closed separately and the main- and branch-header valves used for sectionalizing.

Remote-Control Location

Design and placing of a central switchboard must be carefully thought out. The location should be as near the main means of exit as possible, as plant operators in case of trouble will move toward this point. With the open air in view, a man is more apt to regain his composure and presence of mind than when called upon to act hurriedly and then bolt for his life.

Such stations should never be placed in steamproof vaults adjacent to the boiler room and without means of safe exit. They will be useless in emergencies, as the operators will not travel in that direction. The operation of switches to shut the valves should be as simple as possible, preferably by breaking a protective glass window and pushing a button.

Under no consideration is it safe to open master valves from a remote point which may be opened locally, either by hand or electrically. In order to allow the operator to see exactly what he is doing, the face of the valve-control switchboard should be provided with a plainly marked miniature representation of the complete station piping as shown in Fig. 3, with push buttons to represent the valves. Red and green indicating lights should be provided to show whether the valves

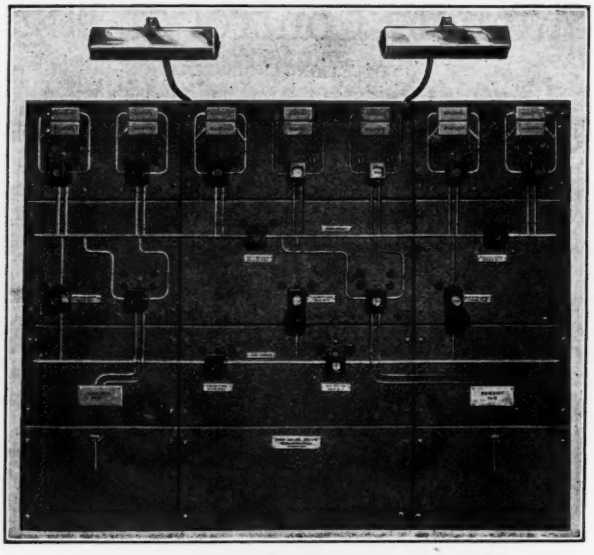


FIG. 3. STATION PIPING MOUNTED IN MINIATURE ON VALVE CONTROL SWITCHBOARD

respond and to indicate the general position of the valves in the complete system.

Motor-Operated Non-Return Valves

Electrical operation of non-return valves has been adopted by many leading engineers. The operation is the same as that required on the triple-duty design, with the exception that the valve stem is driven by a motor provided with reduction gearing, as shown in Fig. 5. Their action under most extreme conditions is positive, provided that the motor control is of the proper design and application. The valves are ideally located with

heater outlet and where vibration due to the whip of a broken boiler lead would not be excessive on account of the valve being securely anchored. They close easily under normal conditions, and for emergency closing should be provided with ball thrust bearings to eliminate the closing friction as much as possible. The control unit should be bolted directly to the yoke and geared to the stem through the yoke nut which is of the rising-stem type. The travel of the disc is not more than one-quarter of its diameter, so that quick closing is possible. Although ruggedly built, this valve will not stand much jamming, and therefore calls for a special type of motor control to prevent it.

There is only one safe point of closing, and that is when the discs and seats are in perfect contact; to effect this the motor drive should have an automatically operated mechanical clutch completely disconnecting the high-speed armature and gears from the motor at the moment of closing, thus eliminating its momentum and allowing the motor armature to come freely to rest. Without this clutch the limit switch must be set to stop the motor before the valve reaches its seat, and a certain

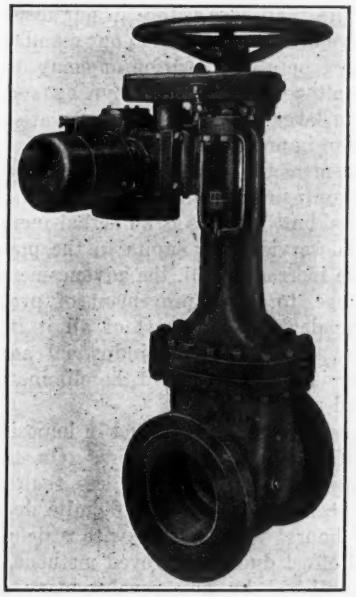


FIG. 4. BOILER LEAD VALVE WITH MOTOR AND GEARS MOUNTED

amount of drift due to the momentum of the armature and gears must be depended upon to seat the valve.

This drift depends upon the resistance to closing, which distinctly varies with line conditions; for instance, when the valve is closed with balanced pressure and there is no flow in the boiler-lead line, there is no resistance to the disc and the electrical limit must be set to trip just at the point of closing so that the disc can drift into its seat.

Assume, then, an open-end pipe condition with steam blowing to atmosphere, during which the disc encounters excessive resistance. The moment the electrical limit opens, the velocity will overcome the momentum and act as a brake, thus causing the motor to stop instantly and before the valve is actually seated. The non-return or globe valve must seat tightly and has no leeway to travel as has a gate valve. Therefore it should be made to seat tightly under all conditions and without jamming or strain.

Types of Gate Valves

Tests at the Essex Station showed that valves of this description up to 10 in. in diameter may be safely closed under emergency conditions, and from a careful study of their behavior it seems safe to recommend them for line protection up to 12 and 14 in. in diameter. Data on emergency closing of valves of above this size and up to 22 in. are not available and the safest con-

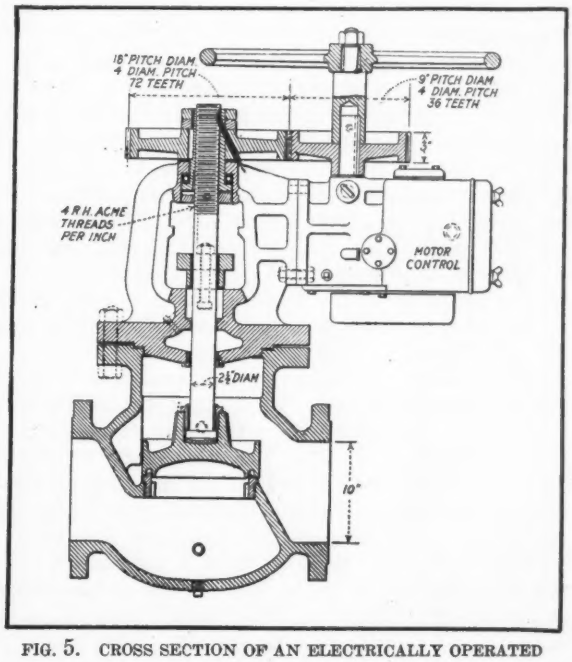


FIG. 5. CROSS SECTION OF AN ELECTRICALLY OPERATED GLOBE VALVE

struction would be to machine the guides, provide the yokes with ball bearings, and attach a control unit of extra large capacity. Valves of this size are used generally for line sectionalizing, and no attempt should be made to close them quickly.

For emergency closing with an unknown direction of steam flow in the line, there seems to be little choice as to the type of gate-valve construction between the solid-wedge taper seat, the split-wedge taper seat, and the parallel-seat Hopkinson type. A valve of each type was tested at Essex Station and examination showed that none of them was excessively affected by the strain.

Motor control valve equipment duty is extremely severe and without doubt necessitates much special construction. The motor must be of the totally enclosed type and provided with ball bearings of excessive diameter. It should be bolted directly to the reduction-gear casing, leaving no coupling or high-speed shafts and bearings exposed. It should be series wound with such characteristics that it will automatically slow down upon the application of load caused by the valve disc passing into the seat. This is the surest means of protection against cutting of the disc and seat rings.

Reduction gears should be of heat-treated steel on account of their compactness and the excessive strain that may be applied, and should be continually immersed in oil. Any oilless or self-lubricating type of bearing for

either the motor or slow-speed shaft should be avoided on account of its inability to withstand excessive heat, long periods of rest, and the accumulation of dust in the bearing.

On account of the excessive drift of the motor armature and gears after tripping, a declutching device should be provided to enable the valve stem to be stopped automatically at a predetermined point without jamming. In the same casing should be provided a self-contained electrical limit which is capable of breaking the main motor current without arcing and so geared that operation of the valve by hand will not throw it out of adjustment.

Valve-control systems should be connected to the most reliable source of current in the station, which is either the direct-current exciter or switch-control battery circuit, as it is equal in importance to any piece of auxiliary machinery. The voltage should not exceed 250, firstly, because direct-current battery circuits of this voltage are standard, and secondly, because higher voltages would cause an unnecessary strain on the closely packed windings. Valve motors are thrown directly across the line without resistance and encounter at the same moment their full mechanical strain due to a tightly seated valve.

All conductors should be suitably protected by fuses having a capacity equal to the full-load starting current of the motor, and fuses rather than switches should be provided for disconnection. The cable should be chosen according to the location, and for the operation of high-pressure superheated-steam equipment, should have an asbestos heatproof covering. It is a good plan to end the rigid conduit within 3 ft. or so of the control unit, and from that point use a flexible loop of Greenfield or similar duct. This will allow considerable vibration in the pipe line without affecting the cables, and will further enable the control unit to be freely moved.

Every electrically operated valve should be opened and closed at least once a week, preferably under load conditions if possible, and an examination of the internal parts should be made at least once a month and all records of such tests and examinations kept on file.

Holding Onto Prosperity

HOOVER DISCUSSES THE ECONOMIC SITUATION OF THE COUNTRY BEFORE THE U. S. CHAMBER OF COMMERCE

IN AN ADDRESS before the United States Chamber of Commerce at New York City on Tuesday, May 8, Herbert Hoover, secretary of commerce, discussed the economic measures needed for "holding onto prosperity."

"During the past few weeks," said Mr. Hoover, "there has been a distinct note of caution at our rapid industrial recovery. I have shared in this, but some have gone so far as to fear that we are entering a period of inflation or danger of collapse. Caution is the greatest safeguard to our continued prosperity, but caution need not be timidity nor exclusive of confidence and courage.

"There are very definite differences in our present economic position in the business cycle as compared with the situation prior to the collapse in 1920. The government index shows wholesale prices are today about 30 per cent below the crest of that time.

"Increases in price are a necessary accompaniment of business recovery. They are the vital stimulant to production. They do not mean inflation unless they continue to rise after full production is attained or unless they are the result of speculation. We have been steadily increasing our production for the last 18 mo. Yet in the two years prior to the 1920 collapse there was comparatively little increase in production.

"We are undoubtedly in a plane of prosperity and we wish to hang onto prosperity. I am not one of those who believe that hard times have any special advantage in disciplining our souls. We ought to be able to discipline ourselves in prosperity when we have time to do it and having achieved prosperity, we ought to be able to hold onto it.

"There has been in the past decade an unparalleled growth of our industrial and commercial efficiency and our consequent ability to consume. I do not refer to that growth of productivity which should naturally be expected to accompany the increment of 14 millions in our population during the last decade, nor do I refer to the increase in dollar figures due to higher prices. Entirely over and above these contributions to increased figures, we are producing a larger amount of commodities per capita than ever before in our history.

"We have been able to add to our standards of living by the more general distribution of many articles which were either altogether luxuries 10 yr. ago, or which were luxuries to a large portion of the population.

"I wish to impress again that I am not confusing the natural increment that would arise from increased population, nor confusing the increased dollar figures due to higher prices, but that this is an actual increase of commodities and services per capita in the population. It is due to the increased skill, the advancement of science, to temperance, to the improvement of processes, more labor saving devices—but most of all it is due to the tremendous strides made in industrial administration and commercial organization in the elimination of waste in effort and materials.

"Nor has it been accomplished in imposing increased physical effort upon our workers. On the contrary, actual physical effort to-day is less than 10 yr. ago. There has been in this period a definite decrease in the number of hours' work weekly with a definite decrease in physical effort due to improved methods. Nor has it been accomplished by any revolutionary discovery in science. It is the result of steady improvement in management and method all along the line. It is an accumulation of better practice in the elimination of waste. It is a monument to the directing brains of commerce and industry and the development in intelligence and skill of the American workingman. The result has been a lift in the standard of living to the whole of our people, manual worker and brain worker alike. This is the real index of economic progress.

"We have in America an economic and social system based on stimulation of individual initiative. Our ideal is to secure and to maintain an equality of opportunity to all. We have honestly sought over years to find methods by which we could curb those who would dominate the community, and thus stifle the initiative and opportunity of the greater numbers. Nor must we relax vigilance in this particular. But we have also in these times to fight that this initiative shall not be destroyed by those who would divert actual production and distribution into the hands of the Government.

Uniform Costs for Power Plants---II

FACTORS ENTERING INTO THE INTELLIGENT ANALYSIS OF OPERATING EXPENSES. BY ALFRED BARUCH

IN a preceding article the statement was made that the greatest part of power plant expenses are indirect. By this we mean that they cannot be identified directly with production and must therefore be apportioned to the units produced on an arbitrary basis rather than through any formula of exact ratios. For example, it is possible to state in definite terms how many B.t.u. are required to produce a given number of pounds of steam or kilowatt-hours; but it is not possible to tell exactly how much labor will be required per pound of steam or how much oil or waste or general maintenance. In order to determine the cost per unit, it is necessary to add all expenses together and divide them by the number of units produced. If this is all the information that can be derived from the cost records or all the use to which they can be put, no further effort would be necessary to determine the cost per kilowatt-hour than to add all the expenditures as indicated by purchase and payroll books and divide them by the units produced.

Investigation of this matter, however, will show that it is even more important to make a detailed analysis of the expenses of power plants than in the case of a manufacturing plant where the costs rise and fall in rough proportion to the volume produced and furnish an index of some sort as to the extent of expenses and the efficiency of production. But the bulk of power plant expenses are fixed and the mere act of lumping them together and dividing them by the total units produced gives no indication as to whether the cost per unit is high or low, though it does tell the cost per unit during the period considered. In order to determine the efficiency of operation, and by this we mean the ratio of the output to the input, it is necessary to examine individual expenses.

As was pointed out in the first article, the illustrations given are those that apply especially to a central power station maintaining transmission lines throughout the town and operating as a public utility. The reason for this is that the problems of a central station embrace the problems of any power house and all that is necessary to reduce this system to the needs of an industrial power house is to eliminate those portions of the description which do not apply and to use the rest.

For a central station the word maintenance has naturally much greater significance than is the case with an industrial power house. In fact, maintenance in a public utility is a department by itself and in distributing the cost of operation it is necessary to resort to details and to records that have no place in the factory power plant.

STORES DEPARTMENT

In a central station the stores department will have such a variety of supplies on hand that it is necessary to provide perpetual inventory records in order to avoid the troubles that visit any store-keeper who does not know what he has on hand; in fact, the punishment is much greater here if service is interrupted because the storeroom has run out of supplies unexpectedly. A manufacturing plant has its earnings deferred in case of such an interruption. A central station has suffered an irreparable loss when a breakdown takes place. At times, this loss mounts in geometrical proportions because some central stations are fined for interrupted service and these fines can be avoided only by anticipating breakdowns.

Stock records contain in their heading the name of the article, a description of it, the size and the units, if possible. The body is divided into four sections which are headed—Ordered, Received, Issue and Balance. The ordered column is divided into sections which show the

STOCK RECORD

DESCRIPTION_____

UNIT_____ SIZE_____ LOCATION_____

MINIMUM_____ MAXIMUM_____ REPLACEMENT LIMIT_____

ORDERED	RECEIVED	ISSUED	BALANCE

FIG. 1. SUGGESTED FORM OF STOCK RECORD

date, order number, quantity and accumulated total. This latter figure is maintained to indicate at a glance whether there is any material on orders in addition to that which has already been received. This permits the store-keeper to reorder at once in case of necessity. The received and issued column are also sub-divided in the same way except that they have no column for quantity. When an order is received or any quantity issued for use, the amount is added to accumulated total and if anyone wishes to know the quantity issued on any specific order all that is necessary is to subtract the previous total from the present one. The difference between the received and issued columns is the balance which is shown in section headed quantity. The remainder of the section under this column contains the current price, the amount and the adjustment. This last section is reserved for any physical counts that may be made which do not check up with the balance on hand. These counts are taken periodically to test the accuracy of the records.

In deciding the quantity of material and supplies to be carried, it is best to establish minimum and maximum limits. The minimum limit represents the least quantity of material that should be carried without putting the plant in the danger of having the service interrupted for lack of essential supplies. The maximum limit represents the greatest quantity of material and supplies that

the operator is willing to carry at any one time. The balance should always range between these two limits and the importance of maintaining these limits cannot be over-emphasized. These limits are determined by experience and to ignore them even for a little while means taking an unnecessary and unbusinesslike risk. They insure the continuous operation of the plant, and prevent the purchase money from being tied up in inventory.

Indirect Expense

Power plant expenses are divisible into two groups—one, the current expenses; the other the fixed expenses. The purpose of this division, rather than of the customary one of operating and maintenance expenses, is that it separates the expenses which may be cut down with decreasing output from those which are fixed and go on regardless of output or revenue.

PARTIAL COMPLETE — MATERIAL CHARGE SLIP — DATE _____ ORDER Nº _____

QUANTITY	UNIT	DESCRIPTION	SIZE	PRICE	AMOUNT

ISSUED BY: _____ FOREMAN'S O.K. _____

FIG. 2. THIS FORM OF MATERIAL CHARGE SLIP HAS BEEN FOUND USEFUL IN KEEPING A RECORD OF EXPENSES

In order to effect an equitable distribution, all expenses that recur frequently are given an expense order number which identifies that expense with the department that incurs it. These expense orders are classified under a numerical basis and each figure in the order number has special significance. For example, all expenses in connection with the boiler room are numbered from 100 to 200; all boiler room labor order numbers run from 100 to 120; all boiler room supplies, from 120 to 150; all boiler room maintenance, from 150 to 200. The purpose of this method of numbering is to bring about an automatic distribution of expenses. If the expense orders are transcribed to a ledger, the clerk knows at once where to enter an order or an expense report by the order numbers. An even simpler method is to have all time cards and requisitions for materials and supplies made out on standard 3 by 5 or 4 by 6 in. cards. These cards when collected may be filed according to their order numbers so that each order number accumulates the charges against it. In this way, it is possible to collect all the charges against any one account automatically, merely by filing the card in its proper place. At the end of the month or the week, whenever the card statement is made up, all that is necessary to determine the charges against each order number or each class of expense is to take the cards out of the file and total it.

Below is given a table which is suggestive of the manner in which the expense order numbers may be distributed. The system of numbering is based on the Zouie decimal system or classification. Later a complete report will be shown, including a hypothetical set of figures so that the methods of comparison should be clear.

Boiler Room

Labor:
- 101—Engineer in charge
- 102—Stoker
- 103—Oilers
- 104—General help

Supplies:
- 121—Fuel
- 122—Water
- 123—Shovel
- 124—Miscellaneous supplies

Maintenance:
- 151—Labor
- 152—Building
- 153—Boilers and auxiliaries
- 154—Engines, turbines and auxiliaries
- 155—Meters, gages, indicators, etc.
- 156—Unclassified maintenance

Operating Department

Labor:
- 201—Foreman
- 202—Operators
- 203—Oilers
- 204—General help

Supplies:
- 221—Lubricating Oil
- 222—Testing Oil
- 223—Waste
- 224—Miscellaneous supplies

Maintenance:
- 251—Labor
- 252—Building
- 253—Transmission
- 254—Generators
- 255—Transformers
- 256—Air Compressors
- 257—Wiring, Conduiting and Installation
- 258—Meters, indicators and gages
- 259—Unclassified maintenance
- 260—Switchboard
- 261—Platform

Installation Department

Labor:
- 301—Foreman
- 302—Electrician
- 303—Drivers
- 304—General Help

Supplies:
- 321—Wires
- 322—Cables
- 323—Poles
- 324—Crossovers
- 325—Small tools
- 326—Tape
- 327—Miscellaneous Supplies

Maintenance:
- 351—Labor
- 352—Truck
- 353—Winders
- 354—Ladders
- 355—Equipment
- 356—Unclassified labor

REPAIR DEPARTMENT

Labor:
- 401—Foreman
- 402—Assistant
- 403—Timekeeper
- 404—Repair department labor
- 405—General help

Supplies:
- 421—Wire
- 422—Plugs and sockets
- 423—Unclassified supplies

Maintenance:
- 451—Machinery
- 452—Small tools
- 453— and Fixtures
- 454—Shafting, belts and hangers.
- 455—Electrical testing apparatus
- 456—Maintenance in air and power line
- 457—Emery wheels
- 458—Oil
- 459—Welding material (it should be equipped)
- 460—Building

METERS DEPARTMENT
- 501—Foreman
- 502—Tester
- 503—Installation men
- 504—Clerical help
- 505—General help

Supplies:
- 521—Wires (Testing)
- 522—Gloves
- 523—Oil
- 524—Testers (Asters) ?
- 525—Tape
- 526—Miscellaneous supplies

Maintenance:
- 551—Testing equipment
- 552—Tank
- 553—Gloves
- 554—Van point
- 555—Miscellaneous supplies

GENERAL EXPENSE
- 601—Executive salary
- 602—Clerical salary
- 603—General repair men
- 604—General labor
- 605—Riggers
- 606—Sickness and accident relief
- 607—Printing and stationery
- 608—Office supply
- 609—Telephone and telegraph
- 610—General stores expense
- 611—Watchmen expense
- 612—General repairs
- 613—Trucking
- 614—Maintenance of building
- 615—Maintenance of yards and grounds
- 616—Miscellaneous expenses

The cost in the boiler room is based on the number of units produced, expressed in terms of B.t.u. In the transformer department the kilowatt-hours become the unit upon which the cost is based, and this unit is maintained throughout.

It will be noticed that the foregoing deals only with the current expenses. The fixed expenses will be dealt with in the next chapter because they cover certain portions of the cost over which there has been considerable discussion and which must be thoroughly explained.

The Oil Hog

By ARTHUR LANE

THE "OIL HOG" was the appropriate name coined by the men about the plant to describe adequately a certain motor bearing. Its appetite for good clean engine oil was appaling. Where the oil went was a mystery, as there was no leakage or throwing of oil from the bearing. Neither was there excessive heating. The "oil hog" was the pulley end bearing of a 40-hp. motor. This motor had been in use for some 12 yr., and is of much heavier construction than the present day type.

A 12-in. cast-iron pulley carries an 8-in. double leather belt, and the motor speed is 900 r.p.m. I mention these figures because they have a direct relation to the cause of the trouble.

I finally discovered the cause of the oil disappearance, after the hearing had begun to smoke one day due to low oil level.

Removing one of the oil hole covers and looking down into the box, I saw at once that the oil rings were throwing a stream of sparks every time the rings chanced to touch the bronze bushing. Static electricity, generated by the high-speed heavy belt, was being communicated to the iron pulley, thence along the armature shaft to the oil rings. These rings acted as a sort of discharge point for the static.

On taking the bearing apart, I found that there was very little space left for oil. There was a heavy deposit of thick black paste exactly resembling the carbon deposit found in gas engine cylinders. The action of the static on the shaft and bushing caused both to become black and pitted. The surface of both felt exactly as though drawing the finger tip over a piece of fine sandpaper.

Of course, the shaft had to be turned down, and a new bushing made.

To remedy the trouble, I made a static collector—that is, a narrow strip of sheet brass with teeth filed on one edge, resembling a saw. This I placed as near as possible to the surface of the belt. An insulated wire connects to this strip, and leads away to a water pipe. This arrangement effectively collects the static electricity, and discharges it into the grounded water pipe.

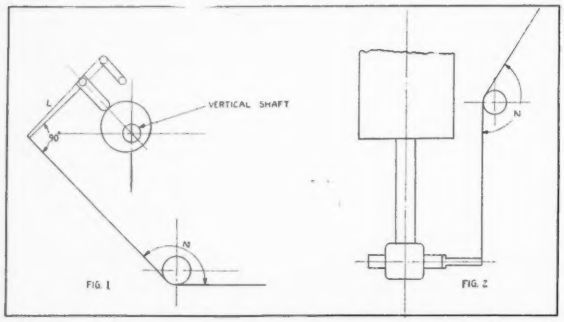
Interpretation of Diesel Engine Cards

CARDS TAKEN ON FOUR CYCLE FULL DIESEL ENGINE SHOW HOW OPERATING CONDITIONS MAY BE CHECKED. BY H. F. BIRNIE

INDICATOR cards enable the Diesel operator to get an idea of what is happening in the cylinders of the engine. While indicator cards will never tell the absolute truth, they will, if certain precautions are taken, give sufficient data to help the engineer keep his engine in good shape.

Besides the absence of knocks, vibrations, hunting and hot bearings, an engine must meet the following requirements if good operating results are to be obtained:

1. Clear exhaust at all loads (except unduly high overloads) without excessive injection air pressure.
2. An evenly distributed load on all cylinders, which can be ascertained by the noise made by the exhaust gases in the exhaust pipes, by opening one after another the cocks to which the indicator is fastened and comparing the intensity of the flames or by cutting off the fuel pump on each cylinder alternatively and watching the r.p.m.
3. Fuel and lubricating oil consumption below the guarantee given by the manufacturer.



FIGS. 1 AND 2. METHOD OF CONNECTING UP THE INDICATOR DRIVING MOTION IS IMPORTANT IF ACCURATE CARDS ARE TO BE SECURED

It is possible for a good engineer to check these points to a certain extent without the aid of the indicator, but there will be a time when his mere senses will fail, and he will have to resort to the indicator.

If accurate cards are to be obtained, care must be exercised in handling the indicator and in taking the cards. The indicator must be rigidly mounted and be kept in good shape, its plunger should not leak and should move freely. The spring of the plunger must not be loose and its tension should be tested once in a while so as to see if it corresponds to the scale marked on the collar of the spring. The spring driving the indicator drum should also not be too tight, as this would put an undue strain on the string connection to the indicator motion. Finally the pencil lever should not show excessive play.

It should be seen that the string connecting the indicator drum to the indicator driving motion does not have too much tension. As soon as the string begins to stretch, the rotation of the drum will be stopped, but not the movement of the pencil lever, until the elongation has been taken up.

As this stretching occurs at the combustion period, the indicator card will then show a pronounced point at the end of the compression stroke, whereas the combustion line might on the contrary be running horizontal; besides the compression and expansion lines will be distorted. We will have to come back later on to this subject, as some engineers have the tendency to accept the indicator card as a perfect mirror of the happenings inside the cylinder and seem to forget that it is but an approximate reflection.

Some Diesel engines have an indicator driving motion mounted on the vertical shaft, others have a system of levers connected to the crosshead (or piston rod) with or without a reduction drum coupled to the indicator. Whatever system is used, it must be seen that the driving motion is transmitted in the right way. For instance, in Fig. 1, the string should always stand square (or very nearly) on the lever L, and in Fig. 2 the string should run parallel to the piston or piston rod. The string can, of course, switch its direction afterwards, but never too suddenly. In other words, the angle should be kept as near 180 deg. as possible.

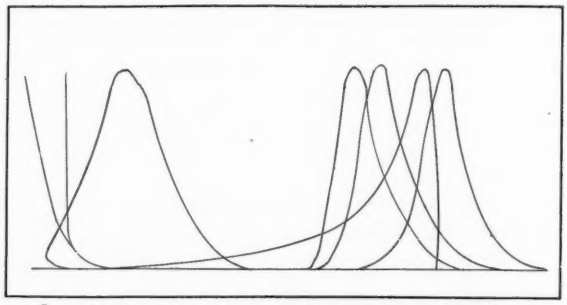


FIG. 3. COMPRESSION CARDS SHOULD BE TAKEN UNDER THE SAME CONDITIONS OF INJECTION AIR PRESSURE AND LOAD

Before putting the indicator in place, it is wise to open the indicator cock connecting the combustion chamber to the outside, so as to blow out the carbon deposit that might have obstructed this passage. It should also be ascertained that this cock does not leak.

With the aid of the indicator, the engineer will be able to take the following cards: Compression diagrams, normal diagrams, offset diagrams and weak spring diagrams. With the aid of special fixtures continuous indicator cards and power integrator readings may also be taken.

TAKING THE COMPRESSION CARD

Compression cards should always be taken under the same conditions of injection air pressure and engine load, for example at quarter load and 600 lb. air pressure. The atmospheric pressure line should be drawn, the fuel supply cut off from the particular cylinder and the indicator drum pulled by hand so as to get lines like those of Fig. 3.

Needless to say, the purpose of the compression cards is to check the height of compression in every cylinder and bring it to the required height. The engine manu-

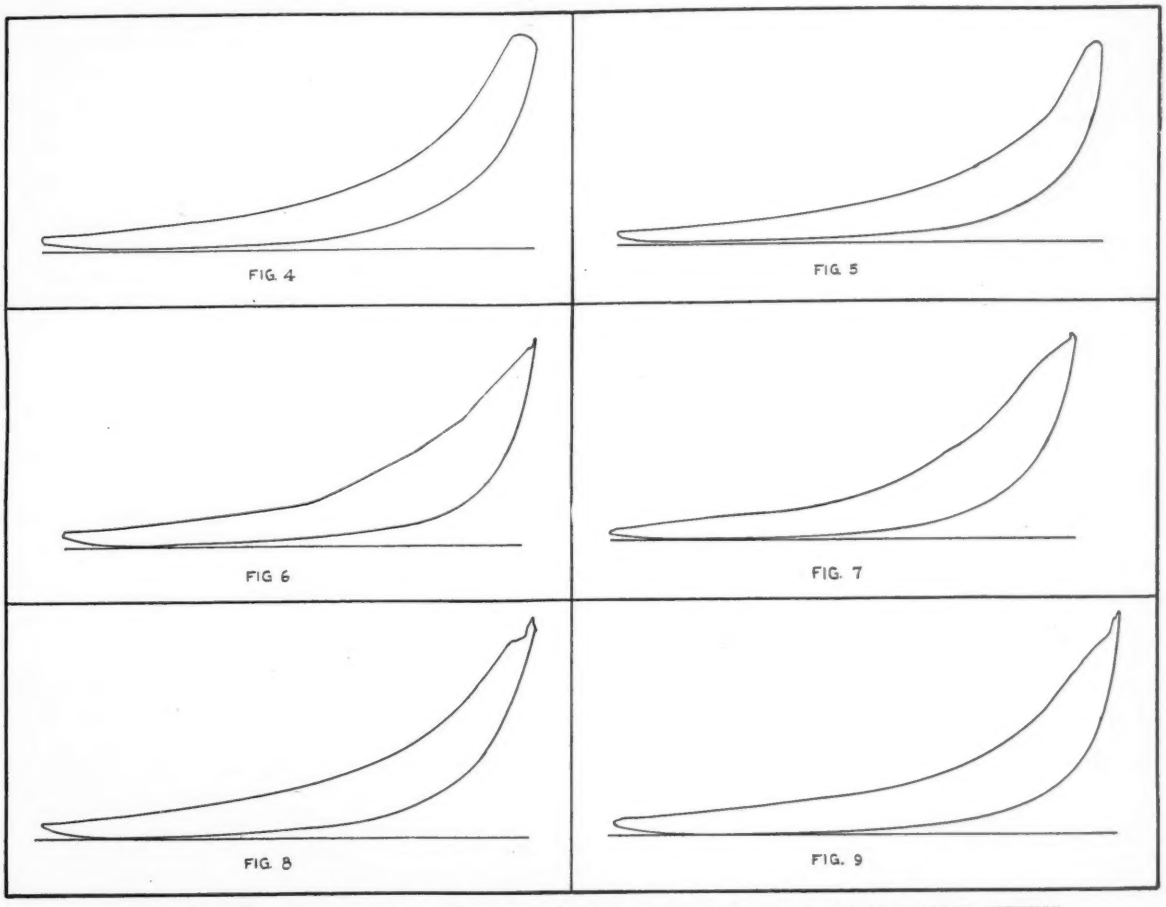
facturer generally gives the thickness of shims that have to be taken off or added to the length of the connecting rod for 1 lb. of compression pressure.

An indicator card taken on all the cylinders will show whether the load of the engine is equally distributed. The engine should, of course, show no signs of "hunting" (misfiring), as it would then make comparison impossible, even if all the cards were taken simultaneously.

As the surface of the indicator card is proportional to the power developed in the cylinder, equal cards mean equal power. An even distribution of load on all the pistons will insure smooth running.

It is, of course, rather hard to judge by sight if a compression or an expansion line is "good." The engineer can compare with adiabatic and isothermic lines drawn alongside the compression and expansion lines from certain points of the diagram, but even at that, he will have no absolute means to tell without intricate calculations if really the lines run as they ought to. We might, for instance, consider Fig. 6 and Fig. 7.

Both diagrams were taken from the same cylinder, under the same conditions of load, injection air pressure, lead and cooling water temperature. The only thing changed was the tension of the string connecting the indicator drum to the indicator motion lever.



FIGS. 4 TO 9. DIESEL CARDS GIVE AN INDICATION OF CORRECT AND INCORRECT VALVE SETTING

Good operation calls for as near a perfect card as possible, as a perfect card means good fuel economy. The main points will be to have good fuel economy, a clear exhaust at normal injection air pressure, and a load distributed equally on all the cylinders. Figure 4 represents a good full load card. The card can be considered good as it shows a constant pressure combustion line characteristic of the Diesel-cycle, a low exhaust pressure, good compression and expansion lines. The top of the diagram is wide and compared to Fig. 5 the expansion line is smooth and not wavy.

Figure 5 on the contrary shows a thin diagram top, a wavy expansion line which coupled together with the fact that the exhaust pressure is high, would indicate "after-burning."

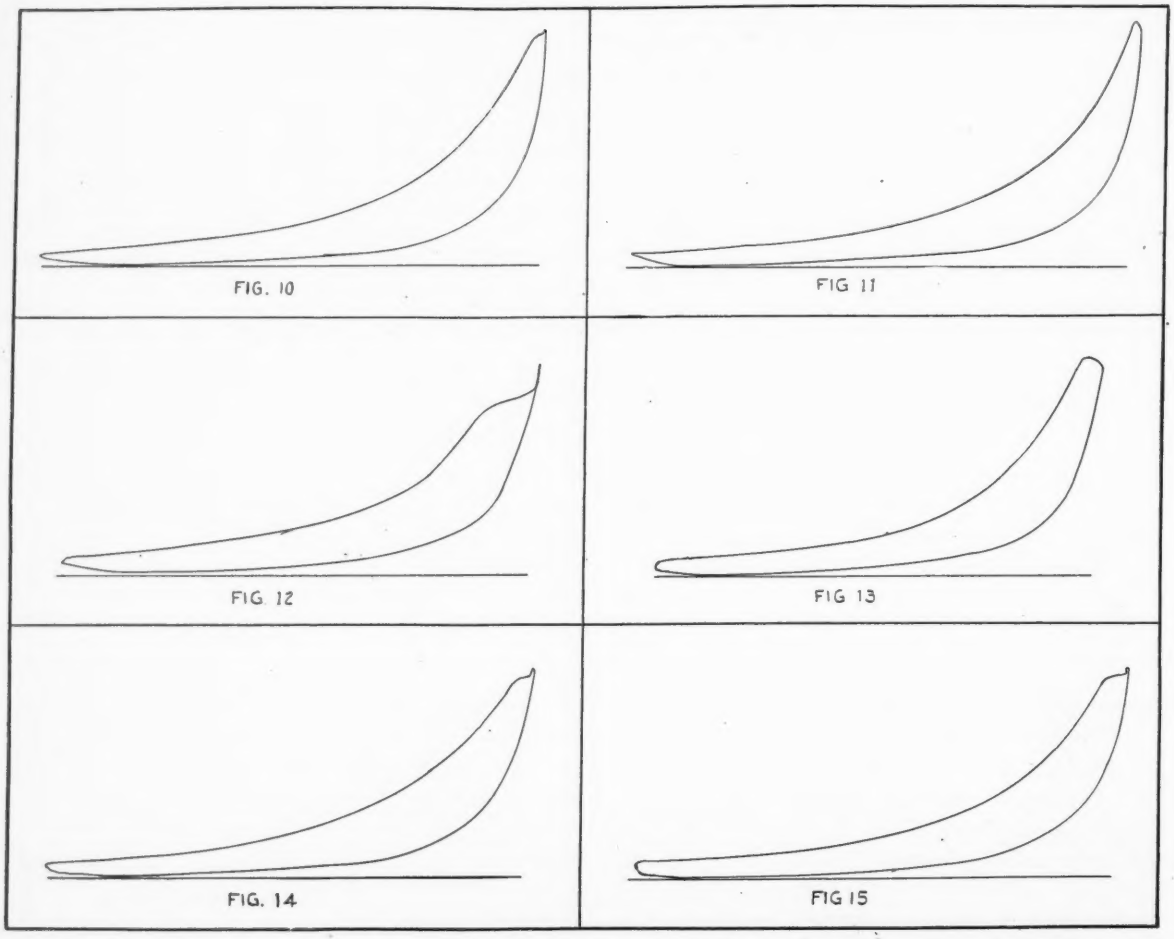
As can be seen, Fig. 6, representing the diagram with the stronger string tension, is quite different from Fig 7, where the tension was less. It is indeed quite a problem for anybody to tell if a certain indicator card is good picture of the pressure-volume changes taking place inside the cylinder. The indicator motion given to the customer by the oil engine manufacturer is generally fairly accurate. By taking the precautions mentioned in the beginning of this article, the engineer will prevent big distortions of the indicator card. As for a definition of a "good looking" compression or expansion line, we might refer to Fig. 4, which gives at least an idea of about how these lines should run. But too many considerations about the exactness of the indicator card might spoil the practical side of it. Let us admit, then,

that the most important precautions have been taken and let us compare the changes which result on the diagram when the setting of the engine is changed.

There are a number of points that influence the combustion of the fuel oil. One of the most important of these is the "resistance" of the fuel valve; meaning by this the number, drilling and shape of atomizing plate, the grooving and length of the atomizing cone, the opening of the spray nozzle and finally also the fuel oil and injection air passages to and in the valve cage. This resistance will have to be adapted to every different kind of fuel oil or, in other words, to the viscosity.

efficiency of the Diesel. But, if at full load, high injection air means better atomization of the fuel oil, at light load, the opposite will be the case. In the latter case the high injection air pressure will chill the combustion chamber, because the mean temperature will be lower and because the smaller amount of fuel lying on the atomizing plates will offer less resistance to the air. Consequently the fuel oil will then burn with difficulty, even, will misfire and thus cause "hunting" of the engine.

It is thus a good thing to run at light loads not only with less injection air pressure, but also with reduced



FIGS. 10 TO 15. EFFECTS OF CHANGING ATOMIZING PLATES AND INJECTION AIR PRESSURE ARE SHOWN IN THESE CARDS

Another important factor is the lead of the fuel needle. A bigger lead will raise the combustion pressure, sometimes very much above the compression pressure. A big lead will help the combustion, but if carried too far will cause knocks and strains (due to the excessively high pressure) which might be detrimental to the engine.

Injection air pressure and (on certain engines) temperature also affects combustion. The first thing the engineer will do when the exhaust is smoky is to raise the air pressure, and it generally helps. High injection air (at full load) is all right as long as it is not carried past the safety point, as one gets then the most out of compressor. The consequence is, as a rule, a better

needle lift. Other changes like varying the outlet temperature of the cooling water, changing the compression of the engine, etc., should only be taken up if really the first mentioned changes should fail.

We will now discuss a few examples of fuel valve setting. Figure 3 represents a diagram taken previous to Fig. 4. The atomizing rigging consisted of one atomizing plate, one cone. The injection air was 950 lb. and the compression 485 lb. The high peak of 530 lb. implies sufficient (if not too much) lead. The thin upper part of the card, the low combustion line and the rather high exhaust pressure pointed to after-burning.

The lead being sufficient, the injection air pressure normal for full load, the cooling water temperature at

the outlet high enough (110 deg.) it seemed logical to admit that the afterburning was the result of too much resistance to the quick entrance of the fuel into the cylinder, consequently, the atomizing plate was taken out, all other items being left the same. The result of the change is seen in Fig. 4.

Figures 9, 10 and 11 show an erroneous reasoning of the atomizing process. The cards were taken on an engine burning heavy crude oil. The atomizing rigging of the card in Fig. 9 consisted of one cone and three atomizing plates. To obtain the card in Fig. 10 two atomizing plates were taken out and the grooves of the cone made twice as wide.

Desiring to improve the card still further, the engineer added to the previous setting one atomizing plate, but increased the lead by 3¼ deg. and drilled out the nozzle plate 0.020 in. bigger. His reasoning was that by adding one plate the fuel would be better atomized. The increased lead would give a better combustion and the bigger opening of the nozzle plate offer less resistance to a fuel already well atomized by the added plate. The reasoning was obviously wrong as the combustion line was all but improved and the expansion line didn't show a betterment although the exhaust pressure was somewhat lowered. The right step to improve the card would have been to cut down the resistance of the atomizing setting by taking out the atomizing plate and eventually widen still more the grooves of the cone. The big increase of lead was a wrong step as the high peak of the card showed 530 lb. on card (compression height 490 lb.).

Cards shown in Figs. 12 and 13 were taken from the same cylinder of an engine, the only difference being that 12 taken first had 850 lb. injection air pressure and 13 900 lb. A difference of 50 lb. couldn't account for such a change in the cards were it not for another factor. As this particular engine was tested out, a peculiar thing happened. The exhaust was smoky at full load, but as the load was taken down to one-fourth and the injection air pressure kept at 850 lb. without signs of "hunting," the exhaust still remained smoky. The air pressure was thus raised at one-fourth load until the exhaust became perfectly clear which happened at 1000 lb.

After maintaining it for some time, the pressure was lowered, the full load put on again and a clear exhaust obtained with 900 lb. pressure. As can be seen, the card in Fig. 13 was also very much improved. The bad card and exhaust of Fig. 12 was thus due to dirty atomizing plates and cones, which were blown clean by the high injection air pressure at one-fourth load. This occurrence was easily verified on some of the subsequent tests made on other engines.

Figures 14 and 15 are intended to show the influence of the injection air temperature. Figure 14 was taken while the engine was running with cold injection air and Fig. 15 shows the result of the use of hot injection air. The improvement is clearly seen, and was, of course, accompanied by a better fuel economy.

Examples given in this article could be multiplied indefinitely, but their object is only to assist the engineer. Every engine is different from the other, and has to be handled in a somewhat different manner; but the few given suggestions will probably help the operating engineer and his engine to come to a better understanding. Treat "her" right and "she" will surely listen to reason.

Steam Cylinder Lubrication*---I

Discussion on Surfaces to Be Lubricated and Manner in Which the Lubricant May Be Applied

WHILE the reciprocating engine, as a means of production of great power, may have been replaced by the steam turbine in many instances, the difficulties of the lubricating engineer in steam cylinder lubrication have not been appreciably reduced. The reciprocating units replaced by turbines were generally of the large, highly developed type, running with fairly constant load, and hence the easiest to lubricate as far as the steam cylinders were concerned. Steam conditions in this type were nearly standardized, and the steam cylinder lubricant was not required to take care of conditions which might vary widely in a short time. For the production of power by means of medium sized or small units, especially in isolated plants or under conditions where the power used may vary rapidly or may be required to reverse direction suddenly, the reciprocating type of engine is still supreme. This type of unit has always been the most difficult to lubricate on account of the varying temperature, pressure, and saturation of the steam. It is far more difficult to ascertain whether a steam cylinder is efficiently and economically lubricated or not than it is to determine the same condition with bearings, because the inside surface of the cylinder cannot be seen or felt while the engine is running. Wear in a cylinder cannot usually be detected except on examination when the cylinder head is removed. Cylinders and valves cannot be examined every day, so the tendency is to use an excess of oil in order to be sure of getting enough.

In discussing this subject we shall consider:

1. What the oil must lubricate.
2. How it can best be applied.
3. The conditions under which it must operate.
4. The selection of oils to meet these operating conditions.
5. How to tell whether lubrication is correct.

Surfaces to Be Lubricated

Broadly speaking, a cylinder oil is required to lubricate every sliding surface which comes in contact with the steam. In reality this includes not only such surfaces as may actually be touched by the steam but those moving parts which are heated by it or are under its pressure. The principal parts that must be lubricated are: (a) the admission or controlling valve and valve rod, (b) the cylinder walls, (c) the piston and piston rings, (d) the piston rod and (e) the exhaust valve if different from the admission valve. In addition the oil generally must lubricate the main stop valve and throttle. These various surfaces are usually under different pressure and temperature conditions in the same

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machines, and the lubricant must take care of these varying conditions equally satisfactorily. As machines vary considerably in their controlling valve mechanism, we shall discuss that first.

There are in general four types of valves: (1) the slide valve, (2) the Corliss valve, (3) the piston valve, (4) the poppet valve. The slide valve, operating, as it does, with an excess pressure on one side, is exceedingly difficult to lubricate, as the tendency is continually to scrape the oil away from the valve seat, giving a maximum opportunity for wear and leakage. This, of course, could be somewhat prevented if the edges of the valve and its seat could be chamfered; but while this procedure would assist in the lubrication, it would result in poor steam economy and hence is unthinkable. To produce satisfactory lubrication of the slide valve, therefore, the oil film must be continually renewed. On account of this difficulty it has been found impractical

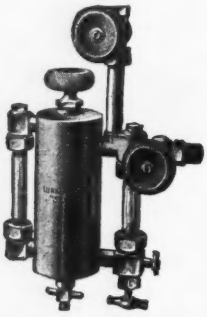


FIG. 1. HYDROSTATIC TYPE OF LUBRICATOR

to operate slide valves at a pressure much over 125 lb. per sq. in.

In the case of the Corliss valve, while there may also be quite an unbalanced pressure it is not as serious as with the slide valve, and somewhat higher steam pressure may be carried. It is quite difficult, however, with this type of valve to maintain a satisfactory oil film at the end of the valve. It is generally necessary to provide special means of lubrication, as an auxiliary lubricator or lubricating line, to this point.

Poppet and piston valves, being balanced as to steam pressure on the sliding surface, are not subjected to this tendency of squeezing the oil from between these surfaces, hence they can carry much higher steam pressures than the slide and Corliss types of valves. In the piston valve, however, a seal must be maintained between the different parts of the valves to prevent leakage of steam and loss of power.

Valve rods are usually comparatively small with little friction, but quite serious trouble may result in the running of the engine if they are not properly lubricated. Their adjustment is very exact and any overheating may cause a change of alinement with a possible sticking of the valve and a waste of power. This is particularly true of the poppet valve stem, which must be well lubricated and free from carbon in order to get quick action.

While the nominal duty of the oil within the cylinder is to lubricate the cylinder walls, the proper lubrication of the piston rings and the piston rod is equally important. Horizontal engines on account of the weight of the piston, require greater care in the selection of a lubricant than do vertical cylinders, and it is considered the best practice in the horizontal type of engine to have the piston supported by a tail rod so that its weight is not carried by the cylinder walls directly. This allows the piston rings to function in producing a seal and not in carrying a load. Piston rings should be rounded on the edges so as to prevent the scraping off of the oil from the cylinder walls, and the rings also should be so designed as to float freely around the piston, thus taking up any misalinement due to unequal expansions or otherwise.

Application of the Oil

Having considered what the oil must lubricate, the next question is how the oil can best be applied. There are two methods in common use: (1) The direct system, and (2) the atomization system. In the former, the oil must be applied to each of the separate surfaces which it is desired to lubricate. In the case of the valves, it is introduced directly into the steam chest, over the valve surface and around the valve rod. With Corliss valves, the oil is applied near the end, as this point is most apt to run dry. From there it works along the remaining surface of the valve. The cylinder wall receives its lubricant either by a feed to the top of the cylinder, from which it drains to the walls, or by one or more feeds to the walls direct. The oil is spread over the surface by the movement of the piston. The piston and valve rods are lubricated by oil applied directly to the gland or stuffing-boxes or to the rod outside the cylinder. With a single-cylinder engine, this system of oiling may not be so cumbersome as to make it objectionable; but when attempts are made to lubricate all sliding surfaces of multiple engines by individual oilers the number of points that must be watched is so multiplied that the chances of failure are greatly increased.

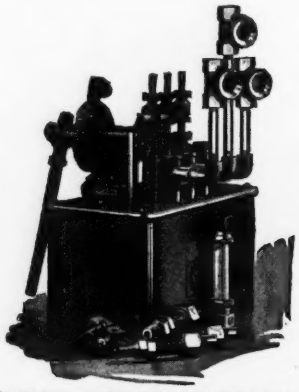


FIG. 2. MECHANICAL TYPE OF LUBRICATOR FEEDS OIL IN PROPORTION TO ENGINE SPEED

Atomization methods for applying the oil aim to eliminate a large number of separate oilers by making the steam act as the carrier of the lubricant. This is possible as the steam reaches practically all of the surfaces to be lubricated. To do this satisfactorily, the oil must be completely atomized before it reaches the parts requiring lubrication. This process is technically known as lubricating the steam. If any of the oil is carried into the cylinder in the liquid state this effect is lost, as it either will be carried out again by the exhaust steam or will not distribute satisfactorily over the surfaces.

Oil must be introduced into the steam line (a) at the best position, and (b) in the most efficient manner. The

ideal place for the introduction of the oil is into the steam line to the cylinder 6 or 8 ft. above the throttle valve. If the point of introduction is too close to the cylinder, complete atomization may not take place, while if it is too far away there is danger that the oil will be deposited on the sides of the steam pipe and will flow to the valve chest in liquid form. This deposition will take place particularly in case there are any bends in the pipe subsequent to the place where the oil is introduced, or if the valve has surfaces or pockets which may form a settling place for the oil. If these conditions are serious, it may be necessary to introduce the oil into the steam pipe close to the cylinder or even into the steam chest direct. This is very undesirable as it gives much less time for atomization and either larger quantities of oil may be necessary or a type of oil must be used which will atomize very easily and may not be the best type for the lubrication of the parts affected. If the oil must be introduced near the cylinder, it may be advantageous to do so at more than one point in order to get a better distribution of lubricant over the rubbing surfaces. Ordinarily, however, one point of introduction of the oil into the steam line is sufficient, and even in the case of multiple cylinder engines under certain conditions sufficient oil may be carried through to lubricate the low-pressure cylinders without the use of an additional lubricator. If, however, there are receivers and re-heaters between the cylinders of multiple type engines, the flow of steam may be so checked that the oil will be thrown out and collect in the bottom of the receivers. In these cases, it may be necessary to install lubricators on the steam chest of the intermediate and low-pressure cylinders, but they need supply only a small amount of oil to make up for that thrown out in the receivers.

In case the cylinder is jacketed by the live steam before its admission to the steam chest, it is generally considered necessary to install the lubricators on the steam chest and introduce at two points if the path of the steam divides. This type of installation requires more oil than if the cylinder were not thus jacketed. Sometimes where several units are on the same steam line, it may be possible to use only one lubricator to supply the oil, if it is placed well back in the line. This, however, is not generally satisfactory, as the steam leads may branch off at such angles that the oil is driven past them and is not distributed properly to all the units.

Lubricators

There are two general types of lubricators used in steam cylinder lubrication: (1) The hydrostatic type, and (2) the mechanical type. In some cases of direct application, small sight feed cups or similar devices are also used.

Hydrostatic types of lubricators, working on the principle of forcing the oil into the lubricating line by means of a head of water produced by condensed steam, are somewhat erratic. Conditions may change the amount and temperature of the water and hence the head, and changes in temperature may vary the viscosity of the oil so that a constant and regular flow is not maintained. The amount of oil flowing into the lubricating line will be independent of the load or speed of the engine, hence the lubricated parts will not receive the varying amounts of oil required to take care of the changing speed conditions.

In the mechanical type of lubricator, as it is generally geared directly to the engine, the oil is forced into the line at a rate which varies directly with the speed of the engine, thus giving a lubrication more commensurate with the requirements. When the engine stops, the lubricator also stops feeding, thus avoiding waste by flooding the engine with oil when it is not in operation. Most mechanical lubricator have sight feed cups so that the rate at which the oil is fed to the line can be ascertained at any time. In the multiple type of lubricator where one piece of apparatus feeds a number of lines, sight feeds with separate regulating devices should be installed in each line. The best types of lubricator will feed the same amount of oil regardless of temperature, viscosity or amount of oil in the receiver.

In the atomization system, one of the most important details is the means by which the oil is broken up into such a fine mist that it will be easily carried by the steam throughout the system and not settle out in the pipes or in dead steam passages. This is accomplished by feeding the oil into the line at a point where the velocity of the steam is high. In some installations, the oil feed line is extended to the center of the main steam pipe and flattened out in the shape of a spoon, so that as the steam strikes it the oil is blown off in a fine spray and mixes completely with the steam. Another method is to extend the oil feed pipe across the steam line and perforate it with small holes. Great efficiency is claimed for the use of fine slots lengthwise on the oil feed pipe, instead of these holes.

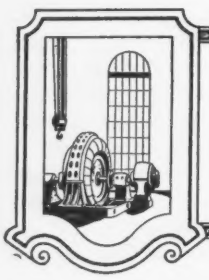
Other things being equal, saturated steam is more efficient in atomization than superheated steam. Which type of atomizer to recommend is difficult, as the conditions of temperature, saturation and velocity of steam, and viscosity and kind of oil, as well as position of atomizer, will all govern the atomization.

Central Station to Burn Powdered Lignite

Four miles east of Boulder, Colo., the Western Light and Power Co. has started construction on a new central station, special features of which will be the burning of pulverized lignite and the imponding of flood waters in an artificial lake from which condenser water will be taken. Plans already authorized provide for a generating capacity of 100,000 kw., although an ultimate possible capacity of 200,000 kw. may be developed. The first 20,000-kw. unit including land and water rights will require an expenditure of about $4,000,000, whereas the completed project will represent an estimated expenditure of $12,000,000.

Primarily the plant will be located on Boulder Lake; however, to assure an adequate supply of condensing water, a dam 2200 ft. long and 65 ft. high will be built to which flood water will be diverted through a 3340-ft. canal. The total water storage capacity will be 280,000,000 cu. ft.

Lignite coal, hauled but a very short distance from either of two fields, will be pulverized at the plant and dried by the waste flue gas. This coal is the characteristic Colorado lignite, low in fixed carbon and high in moisture and ash. It is contemplated that a stack 350 ft. high will be built for the first unit. Steam pressure at the turbine will be 350 lb. with 200 deg. superheat.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Selection of Switchboard Equipment

CONSIDERATIONS INVOLVED IN THE SELECTION OF SWITCHBOARD EQUIPMENT FOR INDUSTRIAL POWER PLANTS OF FROM 1000 TO 6000 KV.A. BY S. W. MAUGER*

NO MATTER how small the prospective plant is to be, it is of importance to give careful consideration to many points before a satisfactory solution can be reached in the selection of equipment for the control of the electric power.

Distribution systems most generally used in industrial plants of the size mentioned above are either 240, 480 or 600-v., three-phase, 60-cycle alternating current systems, especially where, for reasons of economy in copper and insulation material, the power house is located centrally to the places of distribution and therefore the feeder runs are not very long. Where buildings are more or less scattered and at some appreciable distance from the power house, it is sometimes found economical to feed the various buildings at some higher voltage, say 2300 or 6600 v., and step down at the entrance to the buildings, for distribution through the factories to a proper voltage.

When the voltage to be used has been decided, the following points must be considered in the selection of the switching equipment:

1. Possibilities of exchange of power with a power company.
2. Selection of oil circuit breakers.
3. Service required:

(a) Is continuity of service of great importance in the manufacturing of the product?

(b) Is the power to be delivered only during a part of the day or 24 hr. a day

4. Is there any hazard in connection with the switchboard apparatus due to inflammable dust, gas, etc.?
5. Kind of help available.
6. Kind and shape of building available for the power house.
7. Safety to operator.
8. Instruments and meters required.
9. Relays.
10. Most suitable arrangement of panels. (Location of the switchboard in the power plant, arrangement of panels in the switchboard, provision for future extension, arrangement of busses, etc.)
11. Excitation.
12. Voltage regulation.
13. Illumination of the station and switchboard.

POSSIBILITIES OF INTERCONNECTION

If arrangements are to be made for the interchange of power between public service lines and the prospective station, or if all the power used is to be purchased from the Public Service Co., voltages higher than 600 v. will usually be employed for the main feeder lines, with stepdown transformers at the distribution centers. This arrangement will result in smaller conductors for the main feeder lines and still keep the distributing circuits at a voltage suitable for running through an industrial plant. The oil circuit breakers on the high voltage side of the transformers furnish the necessary protection against heavy short circuits, thus the distributing switchboards need not have switches or breakers of such heavy interrupting capacity and will lend themselves more to the use of safety switches shown in Fig. 1 at comparatively small expense.

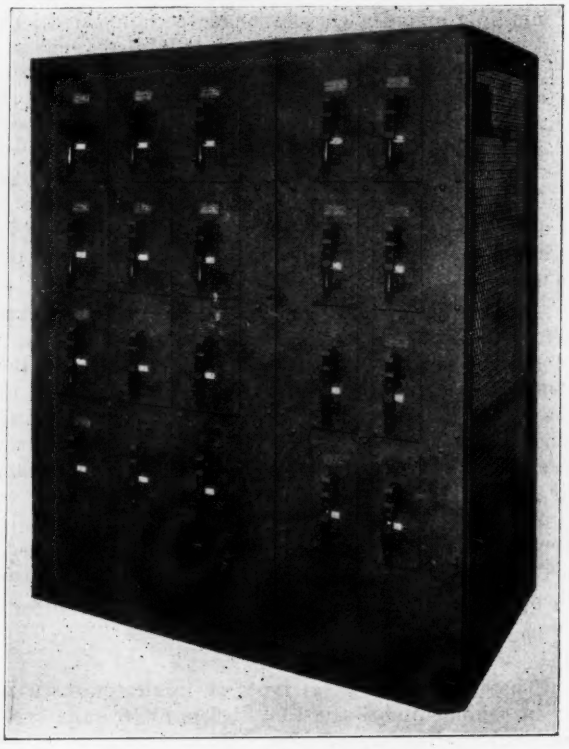


FIG. 1. THIS TYPE OF SAFETY SWITCHBOARD MAY BE USED ON CIRCUITS OF LOW CAPACITY

SELECTION OF OIL CIRCUIT BREAKERS

Oil circuit breakers are built not only in different voltages and ampere capacities, but also with regard to

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the amperes which may be interrupted at given voltages during shorts. The ability to interrupt this certain number of amperes at given voltages is called the "interrupting" capacity of an oil circuit breaker. A very thorough investigation of the total kv.a. capacity back of the main busses (i. e. the generator capacity plus the capacity of power company's system connected to the busses) must be made before the selection of the types of oil circuit breaker with respect to their interrupting capacity can be intelligently made.

Service Required

Requirements for flexibility of equipment will depend very largely upon whether any shutdowns are allowable; in other words, whether the processes of operation, in which the particular plant is engaged, will permit of any periods of interruption, or, whether it is absolutely essential that the machinery be kept running all the time, as in some steel or sugar mills, where even a short shutdown would result in great losses to the manufacturer.

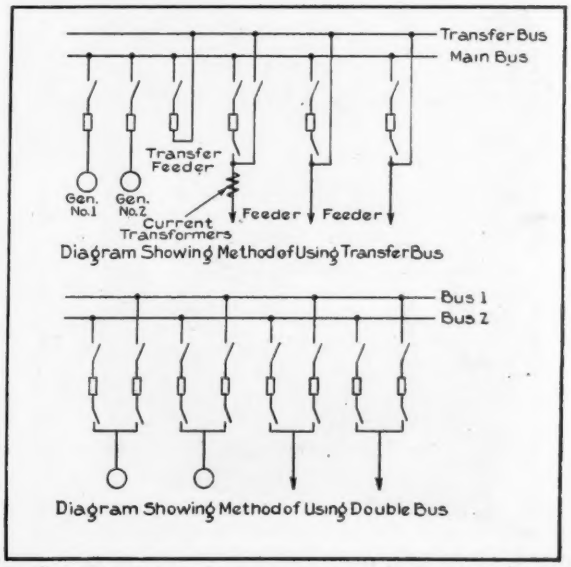


FIG. 2. DIAGRAMS SHOWING USE OF TRANSFER AND DOUBLE BUSSES

If an occasional shutdown would not greatly inconvenience the plant, the simplest and therefore the least expensive of arrangement consistent with good practice would be advisable. In this case, the generators and feeders connected to the main bus would require only one set of disconnecting switches placed between the bus and the oil circuit breakers. If an inspection of an oil circuit breaker is required, the entire circuit fed by the oil circuit breaker must be shut down while the necessary inspection or repairs are being made.

Should, however, continuity of service be an essential requirement of the plant, it will be necessary to elaborate the system just described by an addition of another bus (the transfer bus) or by installing two sets of busses with double equipment of oil circuit breakers and disconnecting switches as illustrated in the diagram, Fig. 2.

With the transfer bus scheme, two sets of disconnecting switches must be installed, one on each side of the oil circuit breaker and the other set for connecting the transfer bus to a point on the feeder, below the disconnecting switches that isolate the oil circuit breaker. The transfer oil circuit breaker can be automatic and arranged to trip from the individual current transformers connected in the line of the faulty oil circuit breaker. Such an arrangement is very flexible and affords inspection and repair of breakers without interrupting the service; it is, however, not so convenient as the second scheme, where the transfer oil circuit breaker and its disconnecting switches are located closely together and enable the operator better to oversee the situation.

Another flexible and safe arrangement is obtained by the use of removable truck type panels. These panels represent a wide deviation from the ordinarily recognized methods of arranging switching apparatus. Such panels are especially adapted for plants where it is desired to keep the hazard to life and property at a minimum and where continuity of operation and flexibility of arrangement are of the utmost importance. In many cases, only one reserve truck need be kept and it may replace any truck with only momentary interruption in service. Special transfer busses on the same principle as shown in Fig. 2 can be arranged in compartments above the truck panels so that a truck can be removed and a spare truck inserted without any interruption of service.

Are Switching Operations Hazardous?

In the choice of proper switching apparatus to be used at the place of distribution much will depend on whether or not there is any hazard due to imflammable dust or gases and furthermore, as stated before, upon the degree of interruption permissible in the work performed.

Fused lever switches are the cheapest apparatus that should be installed to furnish overload protection to a line and then only when the time for the renewal of the fuses (which usually is done by the electrical attendant and not by the operator of the particular machine fed by the fused lever switch) does not hamper to too great an extent the process of manufacture.

Where, however, interruptions should be reduced to a minimum, and the voltage is not too high, overload air circuit breakers should be installed. These can be reclosed by the operator, eliminating thereby the waste of time otherwise spent in waiting for the plant electrician to re-establish the circuit. The two above-mentioned switching methods, however, should be used only where the voltage is less than 440 v. and where there is no danger that gases or dust could be ignited by the electric arc set up in the opening of the device. Where the voltage of the circuits is 440 v. or over or where gases and dust could be ignited by the arc of the switching apparatus, the oil circuit breakers are recommended.

Rust resisting finish must be specified if moisture or gas is present where the switching apparatus is installed.

Kind of Help Available

Where only inexperienced and unskilled help is available to operate the equipment it is advisable to use the modern safety switches or properly installed oil circuit breakers the ordinary open type of switch offering too great a liability to accidental contact.

As previously described, group feeders leading to different central distributing places in the plant, where

transformers and individual feeder dead front lever switches or circuit breakers should be installed, lend themselves most particularly to installations where unskilled labor is required to operate the apparatus. One form of dead front lever switches is so designed that a door under the operating lever allows access to the fuses from the front of the panel; the door, however, cannot be opened while the switch is closed nor can the switch be closed while the door is open. The source of power is always connected to the hinge stud of the switch, so that when the switch is opened the fuses are dead and can be examined or replaced without endangering the operator. These switches can be locked in the open position by a padlock which is a considerable advantage in modern safety practice.

Type of Building Available for the Power House

Type of equipment, whether hand or remote control, will depend largely on the available space in the building destined to harbor the power plant equipment. An ideal arrangement would be where all the switching apparatus is located on the same floor with the switchboard, so that the operator can easily oversee his entire equipment; and in case of isolating one circuit from the busses for sake of repairs or inspection, he will not have to rely on the assistant in charge of the proper set of disconnecting switches.

In deciding to locate all the apparatus on one floor—and truck panels are not used—it must be noted that the more room given to the operator to inspect his equipment and to operate the disconnecting switches, the safer will be the arrangement. Therefore, the selection of small size panels and the crowding of the oil circuit breakers, instruments, transformers and disconnecting switches on the backs of these small panels would not

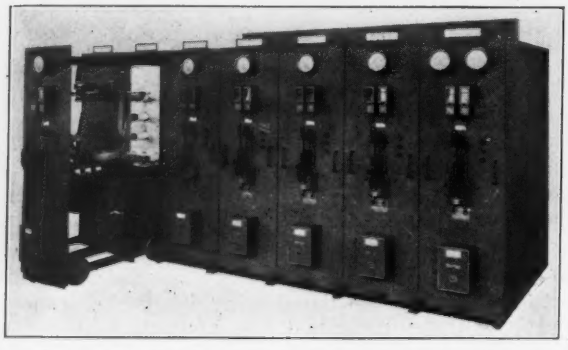


FIG. 3. THESE TRUCK TYPE PANELS GIVE MAXIMUM PROTECTION TO BOTH LIFE AND PROPERTY

meet the safety standards which an up-to-date plant should offer to its employes.

If the little difference in cost between full size panels and the small size panels is not the obstacle which prevents the prospective purchaser from selecting the first kind (and it would probably pay in the long run considering the very high price of accidents) it is far more appropriate to install full size panels with the switching gear arranged remote from the back of the panels so as to afford a clear passageway of at least 36 in. for the operator to open the various disconnecting switches and to inspect and change the oil in the breakers. The pipe mechanism of the breakers should be placed under the floor to avoid the necessity of a false floor over the horizontal operating rod or to avoid making expensive trenches to enclose the mechanism and to present as smooth a surface as possible for the operator to walk upon.

This kind of arrangement is connection with full size panels not only affords safety, but is neat in its design. The busses which otherwise would be visible from the front of the board will be at least from 4 to 5 ft. in the rear of the panels thus not marring the clean cut arrangement of the front of the board.

Conditions, however, governing the layout of the plant have a great influence upon the selection of the equipment and in crowded quarters usually found in large cities, it will be necessary to select a two-story arrangement where the switchboard is separated from the switch gear. In such cases, two types of switch gear would be available for selection; the manually operated

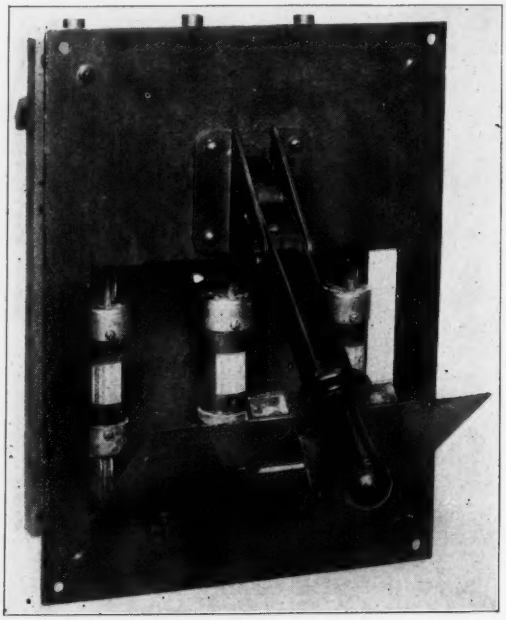


FIG. 4. THE DOOR ON THIS SWITCH CANNOT BE OPENED WHILE THE SWITCH IS CLOSED NOR CAN THE SWITCH BE CLOSED WHILE THE DOOR IS OPEN

breakers, located remote somewhere on the floor below or above the switchboard or the more expensive type, the solenoid or motor operated breaker. The distance between the switchboard and the switch gear for manually operated oil circuit breakers has its narrow limits and where the horizontal distance from the board to the breaker exceeds the safe limit for the use of the ¾-in. horizontal operating pipe, it is well to consider solenoid or motor operated oil circuit breakers; however, one should bear in mind that a storage battery with its charging equipment and a more skilled operator will be required with the latter kind of switch gear. If possible, breakers should be selected of the same type, so as to avoid carrying in stock repair parts of different kind of breakers.

Instruments and Meters Required

The instrument and meter equipment for industrial plants must be selected with the following points in view.

Industrial plants as considered by the writer, would have several generator units to establish a larger flexibility to the system, synchronizing is therefore essential and a bracket containing a synchronizer, and two A.C. voltmeters should be provided. The voltmeters should be arranged one under the other and thereby afford an easy method of checking at a glance, the voltage of the incoming machine with that of the running machine. The generator panel instrument equipment may vary within small limits according to the way in which the operator is accustomed to keep the load of the machine equal.

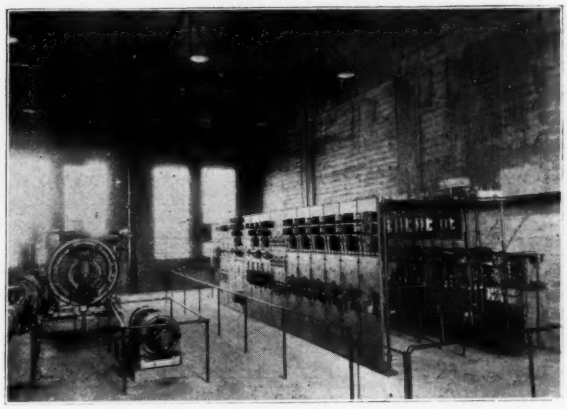


FIG. 5. A WELL DESIGNED SWITCHBOARD IN A PAPER MILL PLANT

The most commonly used equipment would be an ammeter with an ammeter transfer switch, an indicating wattmeter and a field ammeter. The voltmeter should be on the bracket as stated before and connected to the generator by means of an 8-point receptacle and a 4-point plug. The instrument and meter equipment for each main feeder should consist of an ammeter, which will indicate to the operator the condition of load on the cables, a power-factor indicator or provision for connecting to a station P.F. indicator to show which of the feeders has the poorly loaded motors, and a watthour meter to integrate the power consumed by the different departments. It is not absolutely necessary to have an individual power-factor indicator on each panel and a cheaper indication can be obtained by a power-factor indicator located on a central panel and a power-factor transfer switch on the individual feeder panels. The ammeter should be provided with an ammeter transfer switch to enable the operator to check the unbalancing of current where single phase load may be taken of the three phase group feeder. The instrument equipment of the exciter panels should consist of an exciter ammeter and a voltmeter, which can be plugged to any exciter circuit.

Equipment of a panel controlling a tie feeder between the power house of the plant with an outside Power Company, will consist of an ammeter with a transfer switch for checking the load on the cables, provision for synchronizing and reading the voltage, and two watthour meters with ratchet devices to record the incoming direction and outgoing power. A zero center wattmeter may be added for the convenience of checking direction of the flow of power, but this is not absolutely necessary. If the industrial plant will not be required to feed back into the busses of the outside power company, then it is self-evident that the zero-center scale on the wattmeter and one of the recording watthour meters and the ratchet devices will be necessary.

Relays

Generators do not require any overload protection and therefore no overload relays need to be included in their control equipment.

When several generators are working in parallel, however, it is good practice and highly recommended to use differential relays to protect the larger machines against internal troubles.

It is standard practice with some manufacturers, to bring out the leads of generators above certain capacities (around 3750 kv.a.). Three current transformers are placed in these leads on both sides of the generator windings and connected with three instantaneous relays in such a manner, that differential protection is obtained. No current is flowing through the relay windings under normal conditions; but in case of internal short, the current in one set of the current transformers will reverse and operate the relay, which in turn will open the main oil circuit breaker instantaneously.

In case of differential protection of generators, care should be taken to include a field switch which will open automatically by the opening action of the main oil circuit breaker. Such field switches are either solenoid or manually operated with shunt trip.

The protection of the incoming as well as the outgoing feeders should consist of time limit overload relays, two relays per circuit for three-phase, three-wire feeders and three relays per circuit for three-phase, four-wire feeders.

Most Suitable Arrangement of Panels

Panel arrangement must be selected from the standpoint of copper economy as well as grouping of panels to enable the operator to observe and oversee easily the readings and the control of the machine.

Where it is necessary to economize on the number of operators it is advisable to locate the switchboard near the machines so that the operator can observe the generator auxiliaries and at the same time observe the instruments on the board.

For small plants, where the bus copper is not excessive it is common practice to arrange the panels in the following order: the exciter panels, the a.c. generator panels followed by the group feeder only. This arrangement is easily extended in case additional feeders are required. The panels for future generators, however, must be provided for at the first installation so as to avoid tearing up the switchboard structure when new units are added.

Large manufacturers have standardized and catalogued panels which they recommend as having the most suitable selection of instruments and apparatus for industrial plants. This provides an easy method for selecting switchboards up to 2300 v.

Leads placed in conduits should always be of very liberal dimensions as the past has taught us that there is practically no limit to the amount of extension in an industrial plant.

Parallel Operation of D. C. Generators

ALTHOUGH THE PRINCIPLES OF PARALLEL OPERATION ARE WELL UNDERSTOOD, COMPLAINTS REGARDING THIS METHOD OF OPERATION ARE FREQUENT. BY SCOTT HANCOCK

PARALLEL OPERATION systems may be roughly divided into two classes. The most ordinary one is where the generators paralleled are all so closely grouped, as in a power plant, that the resistance of leads, busses and equalizers is negligible. The second class is where the generators are so far separated that the resistance of the line connecting them appreciably affects the division of load, and the resistance of any size of

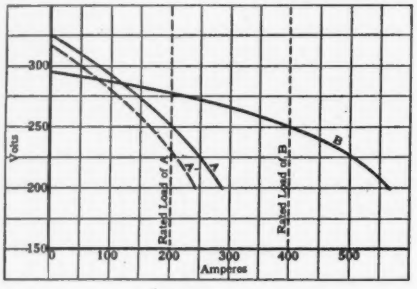


FIG. 1

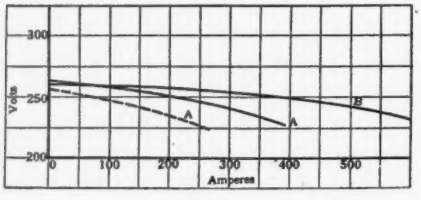


FIG. 2

FIG. 1. TYPICAL REGULATION CURVES OF TWO SHUNT GENERATORS

FIG. 2. LESS DROOPING CURVES OF SHUNT GENERATORS

equalizer that it is practicable to use becomes so great as to make the equalizer useless, and so causes it to be omitted.

Considering only systems of the first class, it is evident that at all times each generator must impress the same voltage at the points of paralleling as does every other generator of the system. Also it is evident that if volt-ampere curves are drawn for each generator at the proper excitation, including both shunt and series ampere-turns then on any curve the current read at the voltage found at the points of paralleling, must be the current that particular generator is delivering, and the sum of such currents for all the generators must equal the load current. It follows that the separate generator currents, the load current, and the voltage all readjust themselves until these conditions prevail, for no other conditions are stable.

SHUNT GENERATORS

In Fig. 1 are shown typical curves of two shunt-wound generators. Curve *A* is for a 50-kw., 250-v. generator with its shunt field adjusted to give rated voltage and current. Curve *B* is a similar curve for a 100-kw., 250-v. generator. It is evident that when two machines so adjusted are paralleled through leads of negligible resistance, and a total load of 600 amp. is applied, each machine will carry its rated load at 250 v. With a load of 300 amp., however, generator *A* would carry 125 amp. at 281 v. and generator *B* would carry 175 amp. at 281 v. If the field rheostat of generator *A* is changed till the new curve produced, *A'*, is such that when 300 amp. total load is applied each generator will carry half of its rated current, then when 600 amp. total load is applied one generator will carry more and one less than its rated current, generator *A* carry 175 amp. at 244 v. and generator *B* 425 amp. at 244 v.

If the two generators, Fig. 1, adjusted to give curves *A* and *B*, are paralleled, and carry a total load of 600 amp., each generator carrying its rated current, and then through a momentary change of speed the small generator carries 250 amp., then its voltage will drop to

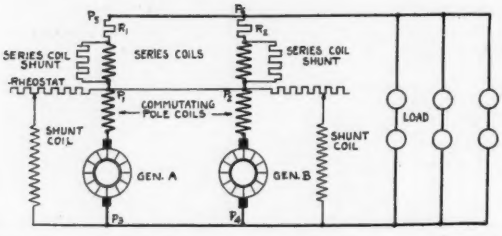


FIG. 3. CONNECTIONS FOR COMPOUND GENERATORS IN PARALLEL

225 v. while the voltage of the other machine rises to 258 v. Such a condition of inequality of voltages must be momentary and the generator with the higher voltage will take an increased load, while the generator with the lower voltage will drop part of its load. This redistribution of load raises the voltage of the generator with the lower voltage, and decreases that of the other generator, till finally each carries steadily its rated current.

If the generators had characteristics as shown in Fig. 2 instead of Fig. 1, and the load becomes momentarily 250 amp. on generator *A* and 350 on generator *B*, the difference of voltage between the two generators would become 7 v. instead of 33 as in the preceding case. It is obvious that the generators producing the greatest corrective voltage (i.e. those of Fig. 1) would be the first to redistribute their load properly and so would be the most stable. Furthermore, in the case of the generators represented by Fig. 2, a slight change in a generator has an extremely great effect on the division of the load. A slight change in the resistance of the field due to its heating up might change the one generator's curve from *A* to *A'*. Under this condition, the load would shift until generator *B* carried almost all of the load.

It is found then that if two shunt-wound generators are paralleled by means of leads of negligible resistance:

1—If each generator has a curve that is decidedly drooping the generators may be satisfactorily paralleled.

2—The more dropping the curves the more stable will be the division of load between the generators.

3—The more drooping the curves the less will the division of the load be affected by slight changes in a generator's curve.

4—The generators may be adjusted by means of field rheostats to give any division of load at any total load desired, but this division will be different at all other loads.

Compound Generators

Figure 3 shows two compound generators connected in parallel in the usual manner. The generators are assumed to be close together, with the equalizer and busses so short that their resistances are negligible. The equalizer is used to keep points P_1 and P_2 at the same potential.

If it is assumed that an equalizer is not used, then the curves of the two generators can be taken as shown in Fig. 4. Curve A is for a 50-kw., 250-v. generator, and curve B for a 100-kw., 250-v. generator. The points P_3 and P_4, P_5 and P_6 in Fig. 3 are the points of paralleling and the curves are taken between those points. If a total load of 600 amp. is put on the two machines, each may for a short time carry the proper proportion of load, that is, its rated load. However, at some time there will be some change, possibly in speed, that will cause

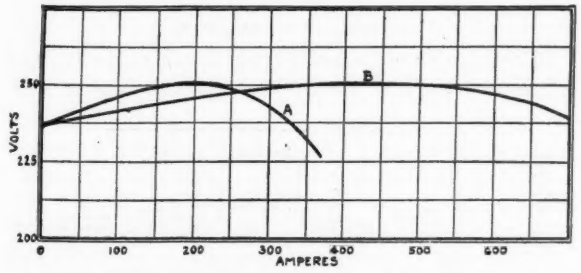


FIG. 4. REGULATION CURVES OF TWO COMPOUND GENERATORS

one of the generators momentarily to carry more than its share of the load. If generator A carried at that time only 100 amp. and generator B carried 500, then the voltage of generator A would become 246 v. and that of generator B would become 249 v. Therefore, generator B would keep taking more and more load until finally it would not only carry all the load but would also drive generator A as a motor. This then is a condition of instability and will not give stable operation. It should be noted that these generators do not tend to shirk their load.

The proper method of adjusting such generators for parallel operation will first be studied, and then the results analyzed. To adjust such generators for parallel operation:

1—Decide what regulation is desired. (Assume for this example that it is 236 v. at no load, and 250 v. at full load.)

2—Connect the equalizer between points P_1 and P_2 as shown in Fig. 3.

3—Disconnect generator B from the line. Break connections between the generator and the lines at points P_4 and P_6, Fig. 3.

4—Adjust the shunt field of generator A to obtain the desired no-load voltage (236 v.).

5—Adjust a shunt on the series field of generator A, if necessary, such that with the same rheostat setting found in (3) the voltage of the generator at full load will be the voltage desired (250 v.).

6—Reconnect generator B to the lines as it was originally.

7—Repeat, 3, 4, 5 and 6, interchanging the generators, that is, disconnecting generator A and adjusting generator B.

8—Connect a total load approximately equal to the combined ratings of the generators, leaving all the adjustments just made unchanged, and measure the current flowing between points P_1 and P_5. Also measure the current between points P_2 and P_6.

9—Adjust a resistance in series with one of the series fields, as R_1 or R_2, Fig. 3, but not both, such that the currents will divide between the fields in proportion to the ratings of the machines. In the case of the generators assumed the resistance should be so adjusted that

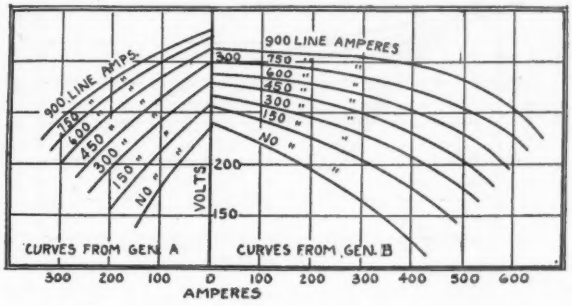


FIG. 5. REGULATION CURVES OF TWO COMPOUND GENERATORS WHICH ARE PROPERLY PARALLELED

one-third of the total current flows between P_1 and P_5, and two-thirds between P_2 and P_6.

10—Check the division of load between the two generators. It should be good.

It is apparent that the series field strength of each generator is independent of the load on that particular generator, and depends only on the total load on the line. The series field then becomes on each generator a type of separate excitation that varies with the line load. The points P_1, P_2, P_3 and P_4 are then the real points of paralleling.

If each of the generators whose curves are shown in Fig. 4 are equalized and properly adjusted as just described for parallel operation with no-load voltages of 236 and full load of 250 v., then the new regulation curves of the generators will be those shown in Fig. 5. It will be noted that there is a different curve for each generator for every different total line load.

If the generators were adjusted as described, the total line load being 600 amp. at 250 v., and if, due to some transient condition, generator B was caused momentarily to carry 500 amp., the following things would happen:

1—The terminal voltage of generator A would rise to 284 v.

2—The terminal voltage of generator B would drop to 230 v.

3—A differential or corrective voltage is therefore produced.

4—Generator A tends to take more load.

5—Generator B tends to take less load.

6—This redistribution of load is continuous till both machines deliver the same terminal voltage when each generator carries its rated load, as may be seen from the curves.

Two compound generators, properly equalized, will operate well in parallel. It should be noted that, considering the effect of its own individual load only, each generator has a drooping volt-ampere curve. The generators then operate in parallel very much as do shunt generators, and all the conclusions drawn concerning shunt generators apply except the fourth.

One thing of importance concerning shunt wound generators, and equally true of equalized compound generators, must not be forgotten. The volt-ampere curve taken at the points of paralleling must be not only drooping, but must be decidedly drooping. A few generators, particularly large compensated ones, may be found that

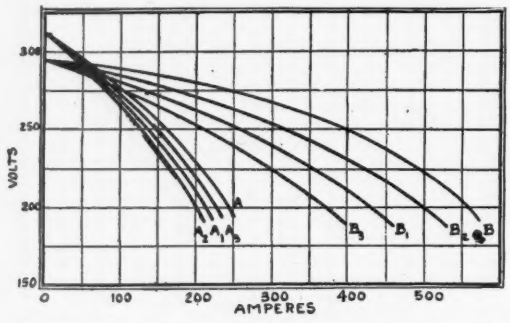


FIG. 6. REGULATION CURVES OF TWO SHUNT GENERATORS PARALLELED THROUGH LINES HAVING APPRECIABLE RESISTANCE

do not naturally have such a decided droop. Before paraleling they must be changed to have such a droop. In general, if two compound generators will operate together satisfactorily in parallel as shunt generators, with their series fields cut out, then they should also operate in parallel satisfactorily as equalized compound generators when they are correctly adjusted.

Generators at a Distance

Two or more generators situated a considerable distance apart are often connected to the same line, and operate in parallel supplying power to that line. This happens frequently in mining service, where one generator will be located at the mouth of the mine, and the other far in the mine. The generators are so far separated that equalizers cannot be effectively and economically used. The operation of such generators is worthy of study.

Shunt Generators

Assume that the two shunt-wound generators whose curves are given in Fig. 1 are connected to the opposite ends of a line whose total resistance, including the total resistance of the wire in both sides of the line, is two ohms, distributed uniformly with respect to distance. Assume that with a total load of 600 amp. applied at a point midway between the generator, the field rheostat of generator A is so adjusted that each generator carries its rated amperes. Curves A and A_1 of Fig. 6 show the regulation curves of generator A when so adjusted, A being taken at the generator and A_1 at the point of paralleling, which in this case is the center of the load, or the midpoint of the lines. Curves B and B_1 are similar curves for generator B. Curves A and B are of theoretical interest only. The curves at the point of paralleling, that is curves A_1 and B_1, are the ones that determine how the generators will parallel. It may be observed that these curves are even more drooping than those of Fig. 1, and so the generators may be expected to parallel even better than when located close together. This would be true if the load were constant in position. If the load should move to a point three times as far from generator A as from generator B, the new curves at the points of paralleling would be A_2 and B_2, Fig. 6. With 600 amp. load applied at this point, generator A will carry 165 amp. and generator B will carry 435 amp., the voltage at the points of paralleling becoming 221 v. If the load should move to a point three times as far from generator B as from generator A, the new curves at the points of paralleling would be A_3 and B_3, Fig. 6. With 600 amp. load applied at this point, generator A will carry 230 amp. and generator B will carry 370 amp. It is seen that although the resistance of the line makes the division of load more stable, and causes it to change less with a change of the amount of load, the resistance also causes the division of load to change as the position of load changes. As the load approaches either generator, that generator takes a larger and larger portion of the load.

Compound Generators

These are more frequently used for this type of paralleling than are shunt generators. Figure 7 shows two

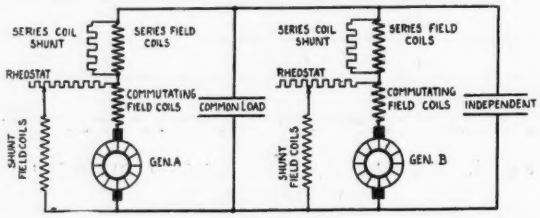


FIG. 7. CONNECTION FOR COMPOUND GENERATORS PARALLELED THROUGH LINES HAVING APPRECIABLE RESISTANCE

compound generators so paralleled. An independent load is also shown as being placed on generator B. Such an independent load may or may not exist. If the generators A and B are the same as those whose curves are shown in Fig. 4, if the generators are not equalized, if the resistance of the line is negligible, and there is no independent load, then the curves of the generators taken at the points of paralleling would be the same as the curves of Fig. 4. These curves are also shown as curves A and B in Fig. 8.

Assume next that each of these generators is connected to the ends of a line of two ohms total resistance, and that the load is midway between the generators. The new curves obtained at the points of paralleling are curves A_1 and B_1. If the total load of 600 amp. is applied at the midpoint it can be seen that the voltage at that point will be 217 v., and generator A will be overloaded, carrying 288 amp., while generator B will be underloaded, carrying 312 amp. It is further seen that the curve of generator B taken at the points of paralleling is decidedly drooping, while that of generator A is slightly drooping. The division of load, therefore, probably would be stable, although not as stable as it would be if the curve A_1 were more drooping. However, the division of load is not that desired. It would be desirable, therefore, to shunt current from the series field of

generator A till the curve A_1', read at the points of paralleling, is obtained. This curve is such that when a load of 600 amp. is applied at the middle of the line, each generator will carry its rated current. This curve, like curve B_1, is decidedly drooping. When so adjusted, and the load concentrated at the middle of the line, the generators should operate excellently in parallel.

When the generators are adjusted for the load at the midpoint of the line and the load changes its position, the generator which it approaches will take more than its share of the load. If the generators are adjusted to give curves A_1' and B_1 when the load is midway between the generators, and the load should then move till it is three times as far from generator A as from generator B, the new curves at the points of paralleling would be curves A_2' and B_2 of Fig. 8. With 600 amp. applied at this point generator A will carry 90 amp. and generator B will carry 510 amp. If next the load should move to a point three times as far from generator B as from generator A the new curves at the points of paralleling would be curves A_3' and B_3 of Fig. 8. With a load of 600 amp. applied at this point, generator A will carry 285 amp. and generator B will carry 315 amp.

When the independent load shown in Fig. 7 is applied, the problem becomes more complicated. Generator B is expected to carry all of the independent load and part of the common load. When both loads are on and the two loads equal the combined rating of the two generators, then each generator is expected to carry its rated load. If, in the case just considered, the common load was only 500 instead of 600 amp., and the independent load was 100 amp., then the shunt on the series field of generator A should be adjusted so that generator A carried 200 amp. of the common load and generator B carried 300 amp. of it.

In paralleling two compound generators for operation with loads as shown in Fig. 7 and under the conditions described, the steps taken in paralleling should be as follows:

1—Determine the average point of common load. This need only be approximate.

2—Determine the no-load and full-load voltages desired at that average point of common load (points of paralleling). The greater the decrease of voltage with increase of load the more constant will be the division of load.

3—Determine the division of common load desired, and the magnitude of the independent load to be used in adjusting.

4—Connect generator A to the line, and disconnect generator B.

5—Adjust the shunt field rheostat of generator A to obtain the desired no-load voltage. No common or independent load is then applied.

6—Apply the rated current load of generator A at the average point of common load, and adjust the shunt on the series field of generator A until the voltage read at the point of load is the desired full load voltage read at the point.

7—Remove the load. Disconnect generator A from the line. Connect generator B to the line.

8—Adjust he shunt field rheostat of generator B to obtain the desired no-load voltage.

9—Apply the independent load determined in 3. Apply at the average point of common load the portion of the full common load that generator B is to carry. Adjust the shunt on the series field of generator B to obtain under these conditions the desired full-load voltage at the average point of common load.

10—Put generator A back on the line, increase the common load to its full load value, and check the division of load.

Summary

It has been found that if two shunt wound, or two unequalized compound wound generators are paralleled by means of lines of appreciable resistance, and a common load is applied between the generators:

1—If each generator has a curve that, read at the point of load, is decidedly drooping, the generators can be satisfactorily paralleled.

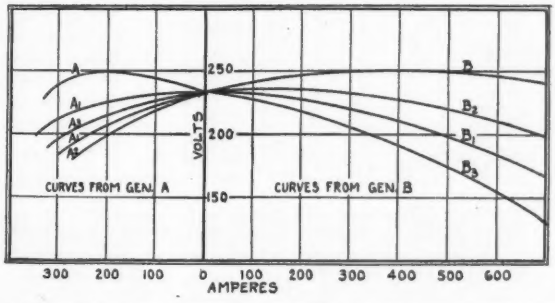


FIG. 8. REGULATION CURVES OF TWO COMPOUND GENERATORS PARALLELED THROUGH LINES HAVING APPRECIABLE RESISTANCE

2—The more drooping the curves are the more stable will be the division of load.

3—The more drooping the curves are, the less will the division of the load be affected by slight changes in a generator's curve.

4—Shunt generators may be adjusted by means of field rheostats to give any division of load at any total load desired, but this division may be different at all other loads.

5—Compound wound generators can be adjusted by means of field rheostats and series field shunts to give any division of load desired at any two total loads desired. No load and full load are the two total loads at which adjustments are usually made.

6—A change in the location of the common load changes the division of that load.

7—If there is an independent load, a change in that load will probably change the division of the common load.

In all the discussion, the common load was assumed to be a concentrated load. If it is a distributed load, the curves presented no longer exactly apply, but all conclusions remain unchanged, and the method of adjusting for parallel operation is not affected.—The Electric Journal.

Over the Chief Inspector's Phone

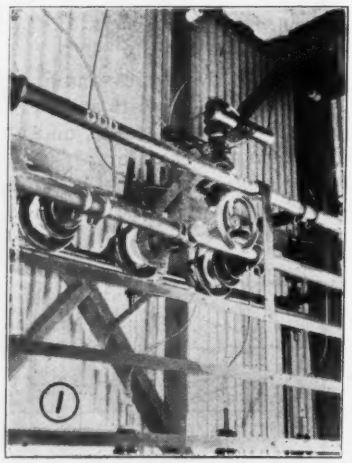
"Hello, this is the engineer at Foothill Power Plant. I've just been reading a boiler book that states, 'Leaks cause external corrosion and the remedy is obvious.'"

"Yes, that's right."

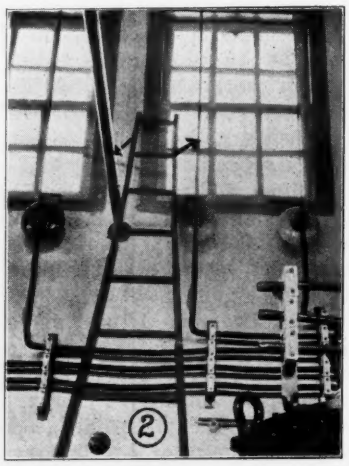
"Well, now can you tell me where I can get this obvious and how it is sold and applied."

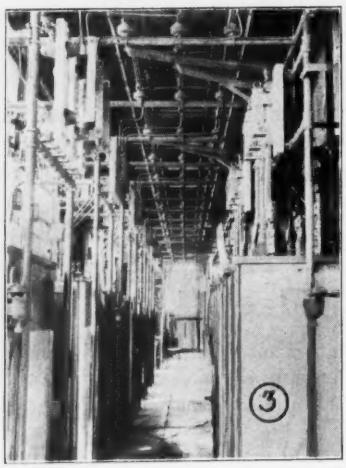
—Locomotive.

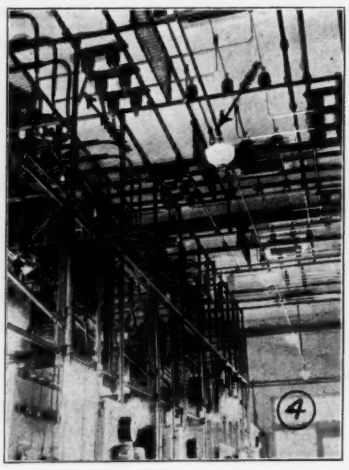
The Cost of Carelessness



MOST accidents are due entirely to carelessness. In many cases after an employer has provided safeguards and a safe place to work, the employe, for whose protection the safeguards are installed, neglects to use them. Often this neglect costs a life. In each of the cases shown in the accompanying photographs reproduced by courtesy of the California Safety News, the man disregarded the safety provisions made for his protection and paid for this neglect with his life.







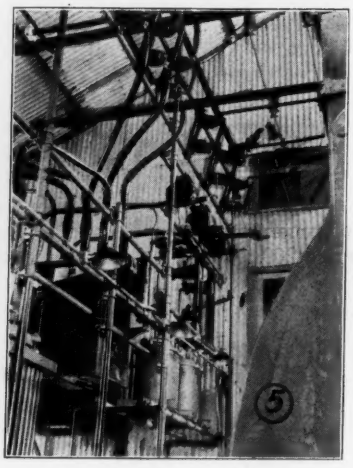


Fig. 1. Lightning arrester room, Ramona substation. The operator in this substation climbed onto the grounded switch support, rested his shins against the pipe above, and reached around the bare 15,000-v. conductor to dust an insulator. His arm came in contact with the conductor. He could have opened the disconnectors—but he didn't.

Fig. 2. Los Angeles substation No. 6. The chief operator of this substation placed a ladder as shown and climbed up to clean a window. He came into contact with the bare 15,000-v. conductor and the grounded pipe at the points indicated by the arrows. He could have opened the disconnectors in this circuit without interrupting service—be he didn't.

Fig. 3. Twenty-three hundred volt switch gallery where an employe was burned by the arc which occurred when one of the 2300-v. busses was accidentally grounded. One of the operators in this station closed a high-voltage disconnector, using a stick to which a grounded wire was attached. The resulting arc caused his death. He had closed the other two disconnectors with the hook-stick provided for this purpose. He could have used the proper hook-stick to close the third disconnector—but he didn't.

Fig. 4. The second operator in this substation was cleaning the lighting units. He placed a step ladder under the first unit and cleaned it safely. He stepped from the ladder to the grounded switch supports and walked along these to the second unit. He placed one hand on the grounded conduit and his shoulder came in contact with the high-voltage disconnector. He could have moved the step ladder to the second unit—but he didn't. Arrows indicate point where the operator came in contact with the high-voltage disconnector and grounded circuit.

Fig. 5. A high-voltage instrument tester stood on a step ladder and connected one of his test leads to the current transformer (the disconnectors were open). He stepped onto the grounded switch support, threw one leg over another pipe, and raised his head into the 11,000-v. bus above. The arrows show the points of contact. He could have connected the other lead while standing on the ladder—but he didn't. Arrow 1 shows where employe stood on pipe support of switch structure. Arrow 2 shows where he placed one leg to support himself. Arrow 3 shows where his head came in contact with 11,000-v. bare conductor.

No amount of money spent by the employer for safeguards could have prevented any one of these accidents. We must have some regard for our own safety. The following bulletin posted in the plant of the Riverside Portland Cement Company tells the story:

The Only Safety Appliances Which This Company
Cannot Furnish for Your Protection Are
"EYES THAT SEE and BRAINS THAT THINK"
They Are the Best Safety Devices Known
USE THEM.

Engineering in the Congo

A Steam Shovel Erector Has a Duel with a Rhinoceros. By Geo. H. Wallace

I WAS SITTING on the large box containing the small parts of the new engine, surrounded by the "gang" right after partaking of the noonday meal. They were the average gang, taking them all in all, and were better than many that are detailed to assist the erecting engineer in assembling the machine.

On some jobs the gang is made up of men from the plant, who may be printers, shoemakers, sheet metal workers, packers, so-called millwrights, Greeks, Armenians, Wops, Chinks, farmers, and occasionally, real fellows.

This gang was of the latter type and was above the average. All were American born with one exception, and all were familiar with the job they had to do, which was, to be the necessary "man-power" to unload, move into the power plant and assist in installing a large engine which the writer was erecting in a large eastern factory.

Al, the hero of the story, was setting next to me, slowly puffing a Missouri briar. I was told by the Chief that Al had put in a few years in Central Africa for some steam shovel company, but at present was working for me on the "bull gang," as his wife was in a hospital in the city and this was a convenient place for him in the meantime.

I had heard a great deal about Al. He said little but did a great deal of thinking, and I knew by the way he handled himself and the tools, that he had considerable experience with machinery. The Chief said that Al had also had considerable experience with wild beasts, wild people, both men and women, and wild machinery, over in that out-of-the-way region and that if I could get Al to loosen up, that he might say something worth while.

As a preliminary to the loosening process, a few really good cigars from day to day started things and today while the boys were spinning yarns Al took it all in and seemed to be in a reminiscent mood. The conversation had drifted around to the usual happenings in the lives of the bunch, which were all the way from getting caught in a cellar full of ammonia, to having a real peeved and warlike bear take possession of a sawmill engine room and try to stop the engine by grabbing the connecting rod.

"Al, you must have had some experiences with your steam shovels over in that God-forsaken continent that were a little different from those of the rest of us, haven't you?" I asked as a feeler. Al muttered a mechanical "thanks" for the cigar that I gave him and after putting away his pipe and lighting the cigar said slowly, "O-oh, y-e-s, if you want to put it that way, we did have some rather exciting times.

"It is one thing to set up this big engine here, right in the heart of civilization where you have a crane and jacks, and bars and tackle, and sledges and chains and blocking, and a more or less efficient gang" (and he looked at the rest of the bunch and laughed), "but it is an entirely different matter to go into the wilderness of Africa a couple of hundred miles and lug overland through the wilderness everything that you expect to need, and then set up several 6-yr. steam shovels with nothing but a lot of Zulus that at any time might take a notion that you were some kind of an evil spirit and skewer you to a tree with a nice little javelin.

"I put up four shovels in 4 yr. over there and 'enough is too much.' Out there in the brush there is absolutely nothing. Our appliances were meager. We cut down small trees for rollers, and also for skids and braces. In fact there wasn't a piece of a board or a plank nearer than the ocean, and what we wanted we had to make out of a tree.

"We had a few rope tackles of small size and some wrenches, and with these we assembled the smallest of the shovels and with this we assembled the others. There was only one white man on the job at the mines besides myself, and he was worse than useless. Guess he was wanted some place.

"Our first troubles began when we started overland with the ox teams, pulling the parts of the shovels on rude carts, or wagons, or on skids not much unlike the old-fashioned 'jumpers' that are used in logging operations.

"There were a few white men on the job freighting the stuff, but they were Burghers and they spoke a mixture of Dutch, Zulu and some other dialect that was an unknown tongue to me. I never did learn what they were talking about, only when they said dammit.

"About once a day on the first trip, we had an encounter with a snake. These boas would hang from a tree and wind their last 10 or 15 ft. around an ox and if prompt measures were not used there would be one less ox in just no time.

"When we started, I wondered at the large number of one man crosscut saws that were stored ready for instant use; also some old cavalry sabres sharpened like a razor and some axes.

"The first day out, one of those snakes wound around the lead off ox of my team and before I realized it, the ox was lifted off the ground. One of these old bewhiskered bushmen said dammit, grabbed one of those old crosscut saws and proceeded to play a tune on the snake as he was stretched tight between the tree and the ox. About two rasps of the bow over this living bass fiddle and the snake snapped in two. The ox was saved, but a few seconds more would have been fatal. The natives had stewed snake for supper that night.

"Next day it was a lion. He thought that an ox tied to a wagon load of iron was a better bet than an antelope or a zebra that he would have to chase. Soon those natives had him so confused that he could not face them all at once, and he found himself so full of spears that he could not put his feet on the ground.

"A couple of days after that a water buffalo got our scent and charged. I got in bad by reason of a red shirt and he soon singled me out and came for me full tilt. The only way out was over the huge dipper that was on a low wagon. I lost no time in going over and just as I landed on the other side, the buffalo, having so much momentum that he could not stop, hit that dipper like a locomotive and knocked it off the wagon.

"He must have struck some projecting bolt or rivet, for the impact knocked him almost senseless, and before he could get his wits together those Zulus had him punctured pretty badly, and we had some fine fresh steak that night. This is better than stewed snake, or fricasseed lion as I can testify.

Telephone Line Difficulties

"We had a few more adventures before we got to the mines. As soon as we got our permanent camp located, we put up a telephone line to the coast, but this was the cause of more trouble. Out in the veldts where we had to set up poles, the elephants seemed to think that they were scratching posts and broke a number of them off.

"In the wooded regions, the inquisitive little monkeys—and the big ones, too—would climb the trees and try to take the shiny insulators off, which they never succeeded in doing. If they had only let it go at that we would not have cared, but they would do a slack wire act to the next tree or pole. One or two of the little pests would have made the trip, but when the whole troupe of a dozen or two tried it, the wire would break and precipitate the whole outfit to the ground.

"Some of the native tribes swiped some of the wire for ornaments until we instilled it into their minds that the wire was filled with 'bad medicine,' when they let it alone. But the monkeys and elephants could not be scared so easily.

"Several times out near the mines the camp was raided by lions during the night and we lost a couple of natives that way. When it got to be too common, they wanted me to stop it for them as their witch doctors were powerless. Here I was, the only white man on the job and none that knew my job nearer than the states, and then being asked to act as bait for a cute little lion just to save the hides of a few worthless Zulus.

"But I had to make good. I had a stout cage built at the edge of the settlement and a krell, or native hut built over it. In a few days, I got into the cage one night with a shotgun loaded with buckshot and waited. Lots of ideas passed through my mind while I sat there like the Christian captives of Nero, waiting for the lion to come and polish my bones or else have his polished. I can assure you that it is not an act that appealed to me.

"About midnight I had a visitor. I let the muzzle of the gun rest on the cross bar of the cage aimed for the doorway. The lion snuffed around a little in the semi-darkness and then came right up to the door, within 3 ft. of me. This seemed to be the proper time to start the program so I fired both barrels.

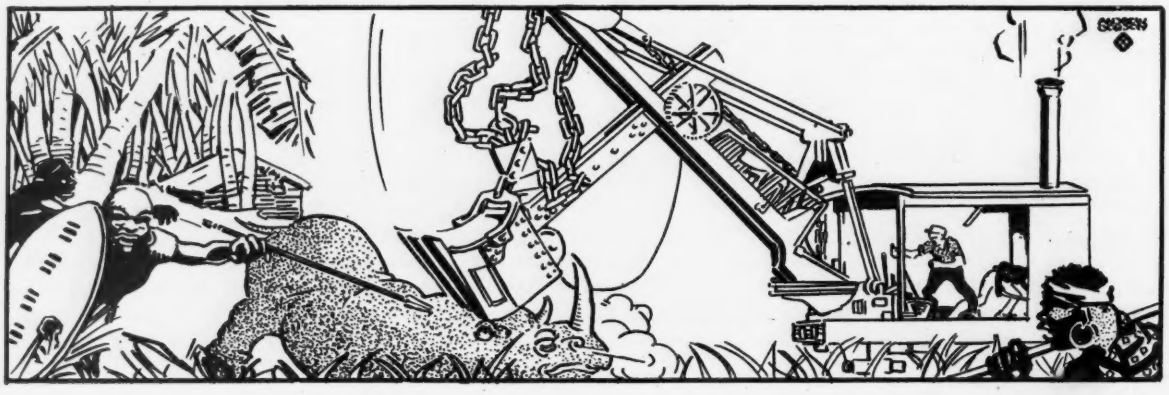
"The roar of the gun brought the natives with torches and we found the lion just where he fell with his noble head filled full of buckshot.

A Duel with a Rhinoceros

"This seemed to put an end not only to the killing of the natives, but to all adventures for quite a while, until the day I had the second shovel under steam for the first time and was trying it out, swinging it back and forth a little to break in the engines.

"Suddenly right in front of me, the brush parted, and a huge black rhinoceros rushed out with blood in his eye. This was the first one we had seen for a year, the only other one being seen one day when out about 10 mi. on a hunting trip. This was evidently an outlaw which had been driven out of the herd or camp by a new monarch, and he was feeling pretty sore about it.

"My native fireman saw him first and drew my attention to him. I tooted the whistle at the beast to scare him away for I was not anxious to do any jousting with a knight like that. But he was game and thinking that the whistle was an acceptance of the challenge, proceeded to engage in mortal combat with a 6-yd. steam shovel.



—AND REVERSING THE ENGINE, I BROUGHT THE DIPPER DOWN ON HIS SHORT MASSIVE NECK

"He launched his 3 T. of flesh and bone straight for the dipper. I dropped it a little so that he would strike the sloping bottom of it, just under the teeth. The impact was terrible and while the force of the blow nearly knocked the dipper off the boom, it floored him and astonished him to say the least.

"I did not dare swing the boom much, as I had no side braces on and to swing it much might capsize the whole outfit; yet, if the rhinoceros took a notion to execute a flank movement and attack me in a vulnerable spot on the side, where I could not get at him, that would indeed be a mess; but I reasoned that this was his first encounter with a steam shovel, he would not be versed in the fine points of the game.

"I swung the dipper a little to one side, enough to uncover the brute, and he jumped to his feet and took after the dipper and dealt it a few glancing and unsatisfactory blows, while I maneuxered a little with the new engines. By keeping the dipper a little above him, and

swinging it in and out, and side to side, he would race after it and try to puncture it with his horn, which was about 3 ft. long.

"He did get it caught in the side lug of the dipper once, and the impact nearly wrenched the dipper loose from the boom. When I tried to raise the dipper to free it, it raised his front end off the ground, which I did three or four times before he got loose. An enemy that could lift him off the ground was something new to him and he was furious.

"He charged all around and in self defense I had to swing to meet him, even at the risk of being tipped over. It seemed better to fight than to keep still and let him get his horn under the outfit and tip it over. Once or twice while I had the dipper on the ground to regain my balance, he swung off and charged it like a load of pig iron, and the resistance of the steel dipper seemed to make him all the more determined to win the fight.

"A belligerent native now appeared with a foolish bundle of spears; but before he could get into action, the rhinoceros chased him into the bush where from a very convenient tree, he threw a few javelins into the hide of the animal with little more effect than if thrown into a stack of hay, only to give the beast a few ornaments. As a factor in the fight, the self appointed matador was a failure, but it had the desired effect of getting the animal right in front of me as he came out of the brush again about a hundred yards away.

"Like the knights of old, I awaited the attack. Raising the shovel up as high as possible, I waited till it seemed just about the right time and reversing the engine, brought the dipper down with the throttle wide open.

"It was a good guess. Just as I expected, he intended to charge me and have it over with at once, but the shovel descended on his short massive neck with a crash like a couple of switch engines coming together. A 6-yd. shovel about half the size of a horizontal return tubular boiler, assisted by the steel boom and a husky engine are not to be despised.

"It nearly put my steam shovel out of business, but I had the satisfaction of seeing that rhinoceros slide down on the grass, dead, with his homely head skewed unnaturally to one side.

"Somehow or other, that seemed to be the last of our troubles, for after that we had no serious trouble with wild beasts and were able to keep our lines open to the coast without difficulty, though a rogue elephant did charge through camp one day like a Kansas cyclone, knocking over a cart or two and a couple of huts, but luckily kept right on going.

"Those Zulus got to be quite handy with tools and could be depended on generally, though they never learned when a nut was tight. If you didn't watch them, they would screw up on a nut till they stripped the thread, split the nut, or broke the wrench.

"By the time I had the shovels completed and ready to run, the mining company brought up four engineers to run them. Three of them stuck, but the fourth went back to the coast on the returning train. I followed on the next after that having put in a little over 4 yr. there without a white companion (if I might except a floater who was no earthly good and who seemed to have come along to get away from the sheriff some place).

"So when you fellows take a hitch on the top half of that flywheel this afternoon with that crane, and a nice new rope, just imagine what I did over in Africa with a block and tackle hitched to the limb of a tree and two yoke of cattle to do my lifting with. Then you will appreciate the blessings of civilization.

"But there goes the one o'clock whistle."

The Cost of Daylight*

By M. Luckiesch and L. L. Holaday

REMARKS ARE often heard to the effect that daylight costs nothing. This is true outdoors, but obviously it costs considerably to enjoy daylight indoors. One of the writers has discussed this subject elsewhere quite a number of years ago, with the hope that architects would give attention to this aspect of natural lighting. Inasmuch as no data on the subject have appeared, the writers undertook the task of computing the costs of natural lighting as at present practiced and to compare these costs with those of adequate electric lighting.

Initial net cost of equipment for natural lighting includes the difference in the cost of the building with and without windows and skylights, the cost of ground area occupied by light-courts and the cost of extra heating system to supply the difference in heat losses from windows and skylights and from the wall replaced by the glass areas. The annual cost of natural lighting includes interest on the initial net cost, depreciation, cost of repairs, washing and extra fuel. Wall space occupied by windows has not been charged to natural lighting, although this is an appreciable item in many cases. The cost of artificial lighting used in the daytime to reinforce daylight has not been charged to natural lighting in making the cost estimates. Deterioration of interiors due to natural lighting and various items of minor importance have been omitted. In fact, computations were confined to the major factors which are quite tangible.

According to the estimates, the initial net cost of natural lighting for dwellings is from 110 to 225 per cent of the initial net cost of electric lighting; for apartments and hotels, from 100 to 140 per cent; for offices, about 160 per cent; and for art galleries, from 80 to 180 per cent. The annual cost of natural lighting was found, for dwellings, to be from 95 to 125 per cent of the annual cost of electric lighting; for apartments, hotels and offices where artificial lighting is freely used during the daytime, from 50 to 100 per cent; and for art galleries, about 135 per cent. In general, it is seen that the costs of daylight are at least of the same order of magnitude as those of electric lighting. This knowledge should make the consumer more considerate of his artificial lighting bills. In fact, economic considerations indicate that there will be many cases in the future where artificial lighting will supplant natural lighting entirely.

When standard iron pipe size aluminum pipe and fittings are used, the line pressure should not exceed 125 lb. pressure for temperatures up to 212 deg. F. For temperatures ranging 212 deg. to 392 deg. F. the pressure in the line should be reduced to 70 lb. per sq. in.

*Abstract of paper delivered before 1922 Convention, I. E. S.

A New Method for Extinguishing Oil Fires

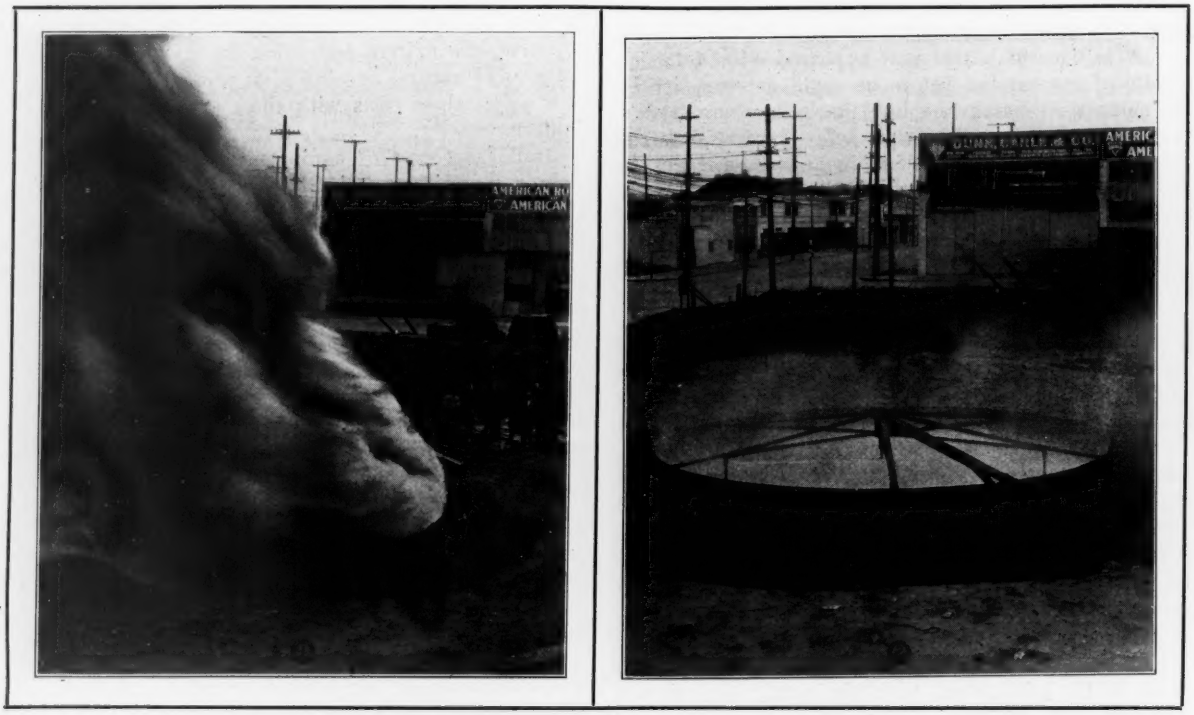
SOLID SHEET OF WATER DIRECTLY ABOVE SURFACE OF BURNING OIL
OIL PREVENTS INGRESS OF OXYGEN. BY CHARLES W. GEIGER

TO DEMONSTRATE the effectiveness of a new type of fire extinguishing apparatus for fuel oil tank fires, the Federal Fire Engineering Co., of San Francisco, Calif., recently conducted a series of highly interesting experiments, which proved the entire success of their method. This method makes use of the Murray water distributor, a device which, when properly applied, is particularly effective in extinguishing oil tank fires, and which operates on the principle of spreading an unbroken curtain of water over and above the surface of burning oil. In this way, the air containing oxygen, the life support of any fire, is not permitted in any great quantities to pass or filter through this curtain of water to the surface of the fire. This is particularly true with the presence of an additional heavy water vapor spray or fog and steam over the burning oil, above and below the water curtain which is the result of the high velocity water curtain striking the sides of the tank, or one curtain against another in multiple installation, and the breaking up into fine globules to form the fog. This has somewhat the same effect as steam in the smothering of oil fires excepting that the steam is applicable only to closed tanks, since in open tanks the heated steam naturally escapes too rapidly to be of much use.

With the method of water application described above the efficiency is the same in either closed or open tanks on account of the comparatively cold water curtain and water spray which is considerably heavier than air.

This company has demonstration grounds adjacent to Engine Company 29 of the San Francisco Fire Department, where demonstrations are given and where perfect results are obtained. They have installed one tank 20 ft. in diameter and 4 ft. high and another tank 12 ft. in diameter and 4 ft. high and have connected both tanks with a centrifugal pump, having capacity of 500 gal. per min. at a discharged head of 100 lb. per sq. in. This pump is directly connected with a 50-hp. 440 v. 1800 r.p.m. motor. On the 20-ft. tank, 1½-in. lines each 7 ft. 6 in. long, radiate from the center of the tank to the separate individual distributors spaced equidistant, circumferentially. The distributor is made of heat resistant metal, its orifice or outlet being restricted by means of an inverted conical shaped disk tip with threaded stem which is screwed into a cross rib in the center opening of the nozzle body, thereby permitting the water to pass through the annular space between the body of the distributor and the stem of the disk tip above mentioned with a curtain-like effect, spreading equally in all directions. Several small holes are also carried through the stem to outer face of disk tip for purposes of additional water jets.

It is the object of this water distributor to obtain not a straight line, large volume, high velocity stream as in most fire nozzles of the common type, but a high



TEST OF NEW EXTINGUISHING APPARATUS AT SAN FRANCISCO

Fig. 1. This oil fire was extinguished by curtain of water in a few seconds. Fig. 2. Same tank shown in Fig. 1 after fire was put out. This view shows curtain of water extending across surface of oil

velocity, thin radial curtain effect of large diameter, and to throw this curtain of water as nearly horizontal as possible when the distributor is in vertical position and with the additional water jets from the outer top to help in breaking up heat pockets or areas at right angles to water curtain.

A 4-in. water meter is installed in the 6-in. suction line leading from a 3000-gal. water storage tank to the pump and a pressure gage, as well as a quick opening valve installed in the discharge line near the pump. For the purpose of regulating the water curtain, as well as being necessary to block off the line not in use, a screw stem gate valve is installed in each line to each individual tank.

There is one other important scientific fact in the extinguishing of oil fires by means of this method of water distribution over and above the surface of the burning oil: All combustible materials have their kindling temperature to which they must be heated before they will burn. Oil is governed by the same law of physics excepting that oil has a certain temperature called its "flash point" at which it will flash when brought into contact with a flame; and another higher temperature called its "burning point," the temperature of the burning gases above the surface of the oil which in itself is sufficient to extinguish any fire.

Steam is also generated, when the water actually hits the fire or heated tank and this steam is of considerable benefit in extinguishing the fire.

If an explosion in the tank occurred due to some unknown reason, there should be no danger of destroying the fire fighting equipment protecting that tank, because of the fact that the water distributors are safely supported and also well protected by structural steel supports from any falling members of the roof supports and thereby provide practically positive fire protection.

Structural members supporting this fire fighting equipment have a tendency of strengthening the shell of the tank to a considerable extent and would undoubtedly be of considerable benefit in the event of an explosion.

On Jan. 31, a fire test was given with the 20-ft. tank. Six inches of oil or 1200 gal. of fuel oil were used and allowed to burn until the entire area was ablaze. The fire was extinguished in 5 sec. with 135 gal. of water. The water required for extinguishing the blaze was actually much less on account of some water pumped after the fire was out and before the pump had been shut down. The pump pressure was 90 lb. and the tank pressure 55 lb.

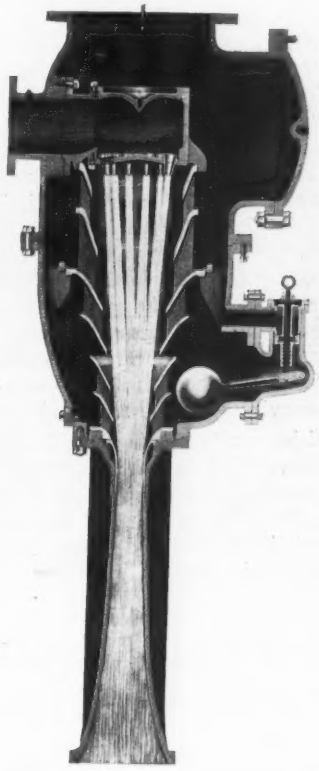
UNITED STATES Civil Service Commission announces an open competitive examination for the position of laboratory assistant, senior grade. The examination will be held throughout the country on Sept. 5 and 6. It is to fill vacancies in the Bureau of Standards, Department of Commerce, at entrance salaries ranging from $1200 to $1380 a year, plus the increase of $20 a month granted by Congress, and vacancies in positions requiring similar qualifications. Examination will be given in the following optional subjects: Advanced general physics, ceramics, chemical engineering, civil and mechanical engineering, electrical engineering, paper technology, physical metallurgy, physics and chemistry, and textile technology. Competitors will be rated on general chemistry and elementary physics, mathematics, optional subject, and education, training, and experience.

Typical Jet Condenser for Central Stations

BY H. C. WOODWARD*

CONDENSERS are ordinarily divided into two classes—(a) surface condensers in which the exhaust steam and the cooling water are separated by metallic heat transmitting surfaces, and (b) jet condensers in which the steam is brought into direct contact with the cooling water and condensed; and the condensate, water, air and non-condensible gases are removed either by gravity (barometric column), by so-called air pumps and removal pumps, or by means of the kinetic energy (energy of motion) of the cooling water.

Selection of the proper condenser is a comparatively simple matter and depends essentially upon the quantity and quality of the cooling water available. If the supply is abundant, and if the water is suitable for boiler feeding purposes, the best condenser to install is a jet condenser. This is the cheapest both in first cost and maintenance charges. The jet condenser should also be used in instances where the condensing water is suitable for boiler feeding, but where the supply is limited and comparatively expensive to obtain. Under such conditions, a recooling system would be installed whereby the warm condensing water from the hotwell can be recooled to a sufficiently low temperature and used over and over again. Leakage and other water losses must, of course, be replenished by an equivalent amount of make-up water.



CROSS SECTION OF JET CONDENSER

* Engineer, Schutte & Koerting Co.

If the condensing water is unsuitable for boiler feed, then a surface condenser must be used. This is so whether the supply of water is abundant or limited. A water purifying system or evaporator is ordinarily used if the make-up water is to be taken from the cooling water supply. Furthermore a recooling system is installed in instances where the supply of water is comparatively expensive to obtain.

One type of jet condenser that is finding favor with an ever-increasing number of operating engineers is that shown in the accompanying illustration. This is known as a low-level multi-jet condenser and has several outstanding characteristic features—the principal one of which is that the condensed steam, water, non-condensible gases and air are discharged from the condenser by the ejector action of the water jets. Air pumps and so-called removal pumps are entirely dispensed with. Since the centrifugal injection water pump delivers the water to the condenser under pressure, it can be designed for low or moderate suction lift and therefore operates at high efficiency.

Essentially this condenser consists of a cylindrical casing, a water nozzle case, a combining tube, and a tail pipe or diffuser. The sectional cut shows these parts. Both top and side steam inlets are provided either of which may be used. The injection water is delivered into the water nozzle case at about 9 lb. pressure (equivalent to 21 ft. of water column), whereupon it is discharged through the tail pipe into the hotwell. The steam is drawn through the annular passages between the tapering rings constituting the combining tube, and condensed by the water jets. The condensate together with the air and non-condensible gases is removed by means of the kinetic energy of the water jets. The condenser creates the vacuum by condensing the steam and maintains it by removing the condensate, air and gases.

The multi-jet condenser is built in standard sizes for steam units ranging from 100 to 10,000 kw. capacity. Single condensers are used up to 5000 kw. and twin arrangements for larger units. The largest single multi-jet condenser built to date is designed to handle 14,000 gal. of water per minute.

Effect of Load Variation on Power Station Efficiency

IT IS characteristic of electric power stations that the output of electricity per 8-hr. shift, or per day, is very variable. During the evening shift, from four o'clock to midnight when the heavy lighting load is on, and during which the evening traffic rush on tramway systems has to be coped with, the output is likely to be several times as much as is required during the succeeding shift from midnight to eight o'clock in the morning. Similarly the Sunday output will in general be much less than that on any week-day, while the week-day outputs also vary among themselves in accordance with the weather and the habits of the community. In the case of steam plants whose sole duty it is to act as standbys to hydroelectric installations, the variations of output during equal periods of time are enormously greater, for one day the station may be doing nothing whereas on the next it may be called upon for its maximum output should there be ice in the hydro plant or trouble on the transmission lines.

This variation in output introduces certain difficulties in station management which are quite apart from those connected with successfully coping with the loads. Every engineer is concerned to run his station efficiently and there is no better check upon operation than a continual comparison of the results obtained. A direct comparison, however, between the fuel consumed per kw.-hr., or the water evaporated per lb. of fuel on different shifts, may be highly misleading. It would certainly not be fair to expect the men who produced every kilowatt hour for, say 1.8 lb. of coal during a shift when the output was 200,000 kw.-hr., to do the same on a shift when the output is only 50,000 kw.-hr. An ordinary station has a variation of output per shift at least as wide as this, while in a stand-by station the maximum output may be fifty times or more the minimum output over equal periods of time. Under such conditions it is of great importance to be able to eliminate, in some way, the effect of the variation in load, so that a true comparison can be made between the efficiency of operation on any shift and that obtained on any other. Only thus can an improvement or the reverse be definitely ascertained and proper credit be given to the men responsible. Experience, moreover, abundantly shows that when a true measure of operating efficiency is instituted, so that no section of the operating staff is unfairly handicapped by the apparently high consumption figures obtained when the load is small, the natural emulation between the shifts of workers rapidly brings about an all-around improvement in results.

At the Dalmarnock Station in Glasgow the output per shift during a certain period varied from 30,000 kw.-hr. to over 230,000 kw.-hr. The coal consumption as stated in the ordinary way was about 3.57 lb. per kw.-hr. for shifts with the lower output, and improved to about 1.8 lb. per kw.-hr. during shifts when the higher outputs were obtained, varying between these limits according to the output. These two figures, although one is apparently nearly twice as good as the other, are really equally satisfactory under their respective conditions, as they both conform equally well with the standard of efficiency ascertained for the station. The operators, therefore, who are using over three pounds of coal per kilowatt-hour may have reason to be quite as proud of their performance as those who produce a kilowatt-hour for less than 2 lb. of coal, and the engineer in charge can allocate praise or blame where it is deserved. The test of efficiency is not the actual consumption per kilowatt-hour, but rather the conformity of this figure, whatever it may be with the standard efficiency line of the station.

The greater the range of output between the various shifts in a station the more important it is to determine the standard efficiency so as to be able to make fair comparisons between the different results. In stand-by stations the apparent results differ so widely that figures given on the ordinary basis are practically meaningless as a measure of the efficiency of operation. We may quote, for example, the case of a steam plant in Canada which was operated as a stand-by to a hydro-electric station. The steam station was called upon for outputs varying from 1000 kw.-hr. to 60,000 kw.-hr. per day of 24 hr. and had to be ready to take over the maximum

load at short notice. When the station produced only 1000 kw.-hr. per day, its average fuel consumption was 56.746 lb. per kw.-hr., while when the output was 60,000 kw.-hr. per day, the average consumption was reduced to 5.711 lb. per kw.-hr. The apparent discrepancy between these results is enormous, yet both are really of equal merit, for both fall on the line given by the equation $C = 51{,}900 + 4.846\ K$, which is the standard of efficiency for that particular station. In this equation C represents the number of pounds of fuel burnt per day, while K represents the output in kilowatt hours over the same period. By comparing the coal consumption for any output with that calculated from the equation, the engineer can form an opinion as to the efficiency of operation during that particular day, without regard to the magnitude of the electrical output. It may be mentioned that, in the instance quoted, the fuel used was lignite slack of low calorific value, so that the results are more interesting by comparison with each other than on account of their absolute value.

These illustrations are quite sufficient to show the necessity of arriving at some basis of comparison between the coal and steam consumption obtained in a power station during shifts when the outputs are unequal. The confusing effect of load variation is of course greatest in stand-by stations. These, however, are consequently few, but the effect is quite pronounced enough in every ordinary power station to render any method of eliminating it highly desirable. Inequality of output is the most disturbing factor in a station where the operating conditions are uniform, and the practical advantage of the method we have indicated is that it enables this factor to be disregarded, so that all shifts can be compared on a uniform basis. Under these conditions bonuses on efficiency can be fairly established, each shift of men being rewarded according to the results they obtain, independently of the performances of other shifts.—Engineering.

Packing Condenser Tubes

Investigation of this subject by the Prime Movers Committee of the N. E. L. A. has brought out interesting changes in current practice. Tubes are being rolled or expanded into one head and packed at the other with reduction of leakage troubles. The fixed end is pointed toward the incoming circulating water to lessen the accumulation of trash. Offsetting these advantages are greater cost for expanding than for packing, and more work in renewing tubes.

As to the packing, in its statement to the committee, Crane Packing Co., said that the use of John Crane metallic condenser tube packing has shown in many plants a reduction in tube trouble, the tubes being fixed into the sheet at one end. Drifting was recommended rather than rolling or expanding, as there is less tendency to crystallize the metal in the tube end. Rounding the edge of the hole in the tube sheet pointing towards incoming water is also advocated, a practice adopted by the Ingersoll-Rand Co., which further uses a beveled edge on the tube end and which is expanded into the sheet, thus getting clear, easy entrance for the water. Wide spacing of tubes is used near the top of the condenser with Crane metallic packing and diffuser ferrules to recover the velocity head of the water, Fig. 1, A. At the bottom of the condenser, where tubes are on close center, metallic packing is used with ordinary

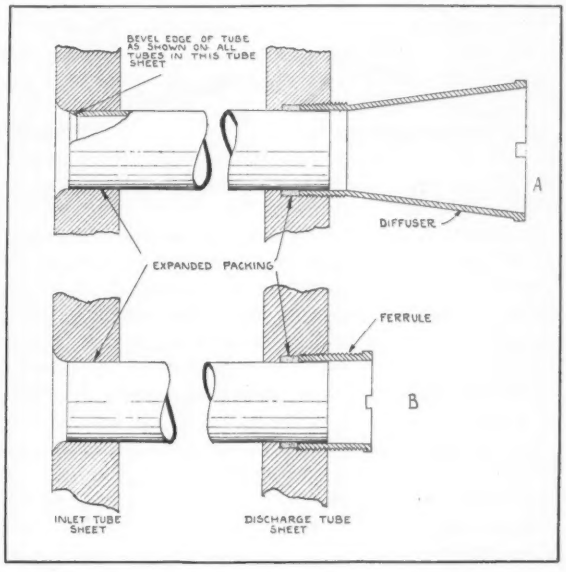


FIG. 1. FERRULES USED ON INGERSOLL-RAND CONDENSER

ferrules, Fig. 1, B. As the tube is fast at the inlet end, no shoulder is needed on the ferrules.

Cutting Steam Costs

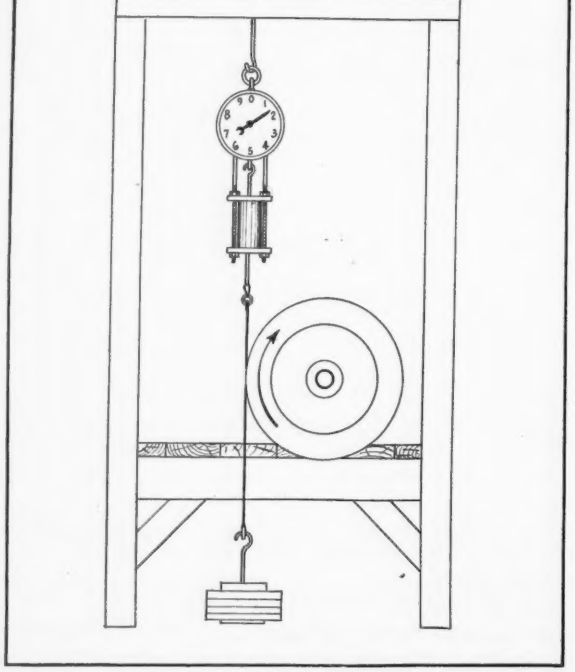
IN ONE plant the introduction of steam meters in order to charge the steam used to each operating department led to such an interest in steam usage that it was possible to avoid the installation of a new boiler, and finally to shut down the spare boiler which it had been previously necessary to keep in almost constant use. The department heads were no longer indifferent to leaky traps on the steam coils, poor insulation on steam pipes, the excessive use of steam in manufacturing processes, etc., for all of the steam used by the department had to be paid for and reflected itself in the cost sheet as uneconomical performance. Not only did the operating department head take an interest in the amount of steam used, but also in the cost of steam. So it followed that the head of the steam department soon found it necessary to know why the cost of making steam was high. Then came the installation of steam meters on each individual boiler unit, and the measurement of coal to each unit so that evaporating efficiency could be determined. Draft gage, CO_2 recorders, etc., of course, followed, for without them the reasons for low evaporation could not be known, but only guessed.

The important thing to remember is that intelligent cost keeping is sure to produce a demand from within the department for the introduction of scientific record keeping which will explain variations in cost, whereas the introduction of scientific methods without first stimulating an interest in economy of operation usually arouses suspicion.—R. B. Wolf, in a paper before the A. S. M. E.

LETTERS DIRECT FROM THE PLANT

Dashpot Used to Steady Scale Readings

WHEREVER the exact output in mechanical energy which is generally stated in horsepower or foot pounds is to be taken on a motor or small engine, the brake test is resorted to as being the most accurate. There are quite a few ways of applying a brake test, not all of which by any means give good results; however, in this article I am not intending to explain the differ-



DASHPOT APPLIED TO SCALE DAMPENS FLUCTUATIONS

ent kinds of brakes, but rather to point out one bad feature that affects most of such devices and a remedy that greatly overcomes that defect.

In nearly all such tests, a dial scale is used to read the back pull as indicated in the accompanying sketch. The pull on such a brake, even if well made and in good condition is always more or less uneven and often tends to bob into a jerky motion that becomes destructive to the scales as well as on the rest of the apparatus. No readings under such conditions are of much account.

To protect the scales as well as to make the readings steady and to dampen down any tendency to such bobbing, an air dashpot was fitted to the standard scales as illustrated which, at least to a great extent, eliminated the former troubles. In this particular case, two quarter-inch holes were drilled through the back frame of the scales into which the two supporting rods were hooked. The two rods were threaded a little over two-thirds of the way up for the purpose of serving as bolts for clamping the top and bottom tight on the dashpot and at the same time holding it in a firm position just a short distance below the scales. The cylinder of the dashpot was made of a heavy brass tube about 3½-in. inside diameter, while the piston and ends were made of one-inch hard wood oil treated.

In this case, however, the piston as well as the rod passing through the end pieces must be a loose fit so as to work perfectly free when slowly moved up and down and in no way interfere with the scale reading. Yet it must be fitted sufficiently close so as to trap the air and retard any fast motion of the piston. Any ordinary mechanic can easily make the device well enough with ordinary tools.

East Orange, N. J. PHILIP G. BERNHOLZ.

Use of Packing in Place of a Gasket

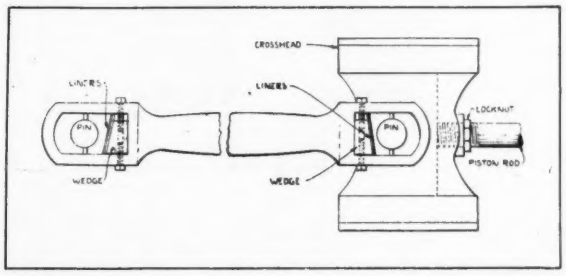
ON PAGE 539 of the May 15 issue of Power Plant Engineering there is an article by J. E. Noble, on the use of thin gaskets with which I fully agree. Because the cross-sectional area of a thin gasket is small, it has a greater holding power than has a thick gasket. The pipe flanges must, however, be exactly square in order to use one. I never liked a gasket that was heavier than a 1/16-in. for all practical purposes, but there are times when one is obliged to use almost anything that is handy in case of emergency. I recall a case that happened to me several years ago, when I had to use a 3/16-in. rope packing for a gasket. I was running a large plant, when all at once I had a blowout on the crank end cylinder of one of engines, which was 28-in. bore by 60-in. stroke taking steam at 140-lb. pressure. I ran until 6 o'clock; in the meantime, I got things ready for a repair. The cylinder had a sole plate under it and the first thing I did was to mark the feet and solt plate so that when we were ready to replace the cylinder I would have my marks to line up to. The foundation was of brick and had a hole running the whole length of the cylinder, with pockets so that the anchor bolts could drop down about an inch below the sole plates. After quitting time, my fireman and I proceeded to loosen the cylinder from the frame; then we carefully dropped the anchor blots down out of the way, and by the use of four wedges forced the cylinder back ½ in., but left the head against the frame, leaving the studs about ½ in. through

the frame to draw the cylinder back in place after packing. We cleaned off all the old gasket, then drew the cylinder up to within 5/32 in. For a gasket, we used about 24 ft. of 3/16-in. rope packing, the cylinder being so close to the head that there was no danger of the packing slipping by to form a bunch. By using a piece of wire with the end bent over to form a hook, we inserted the end of the packing in the hook and pinched it down so it would hold, then by running the wire down under the studs we were able to draw the packing in place. We put in three turns all around and kept them down to the shoulder of the head, all in one piece, then we drew up on the nuts from two opposite points a little at a time until the cylinder was in its original position and the anchor bolts in place. When everything was tightened down, we had a job to be proud of. Oh! yes, we used a few cuss words when we burned our fingers, but we had that plant running next morning as usual, and the best part of it was that the superintendent, a few days later, handed me a nice check, which I shared 50-50 with my fireman.

Grand Rapids, Mich. R. C. HENDEE.

Adjusting Cylinder Clearance

ON ASSUMING charge of a steam plant, having an 18 by 36-in. simple Corliss engine, I found, after a few days, that the engine developed a slight knock in the head end of the cylinder. Upon removing the head, it appeared that the nut on the end of the piston rod had been striking the head, as there was a bright spot on the



CONNECTING ROD AND CROSSHEAD, SHOWING HOW SHIMS WERE INSERTED

corner of the nut, also one on the head. By removing the nipples of the indicator piping, it was possible to determine the amount of clearance on the crank end of the cylinder. Investigation revealed the cause of the trouble. The crank and crosshead boxes had become badly worn, and liners, B, B had been inserted with the wedges at both ends, lengthening the rod enough to cause the end of the piston-rod to strike the head.

Not having the facilities at hand, at the time, to rebabbit the boxes, the piston-rod was screwed into the crosshead at A enough to equalize the clearance. Later, the crankpin box was rebabbited and new brasses were fitted to the crosshead pin and the clearance was adjusted by unscrewing the piston from the cross head, the proper amount. After this was done, the indicator was applied and when a few alterations were made, the engine, although nearly 20 yr. old, ran quietly and efficiently.

Camden, Me. M. M. BROWN.

Air Pockets Between Belt and Pulley

REGARDING the matter of air between belt and pulley, many belt users have discovered that a belt cannot properly pull the load when there are air pockets between it and the pulley. They have furthermore discovered that one of the ways in which to exclude the air is to make the belt soft and pliable. Some users claim that the pliability way is the only way to exclude air.

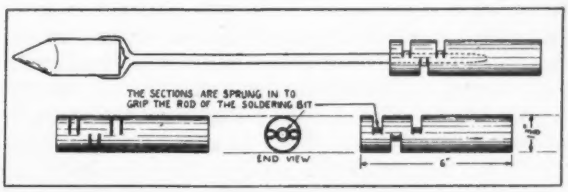
The writer agrees that a belt cannot pull full load when air pockets exist between the belt and pulley surfaces, but I do not agree that the only way to exclude the air is by making the belt soft and pliable. I believe in and always recommend a soft and pliable belt, but there are other ways in which air can be excluded. One way, for instance, is to punch the belt full of holes so that the air can escape through the belt, and it has often been done. Another way is to do the opposite and punch or drill holes through the pulley's rim so that the air can escape through the pulley. Another way, and possibly as good a way as any, surely better than punching holes in the belt or pulley, is to groove the pulley. Thus, some pulleys now on the market possess an air groove for this very purpose. I have in mind a steel pulley with such a groove which was not put there purposely to take care of the air but it is there just the same and it has been found that it solves the air problem very nicely and gives increased tractive power.

I would say that in addition to using a grooved pulley, if one keeps his belts in a nice soft and pliable condition with a good belt dressing, conditions are ideal for taking care of the air. Air pockets are then impossible.

Newark, N. J. W. F. SCHAPHORST.

Simple and Durable Grip for the Soldering Bit

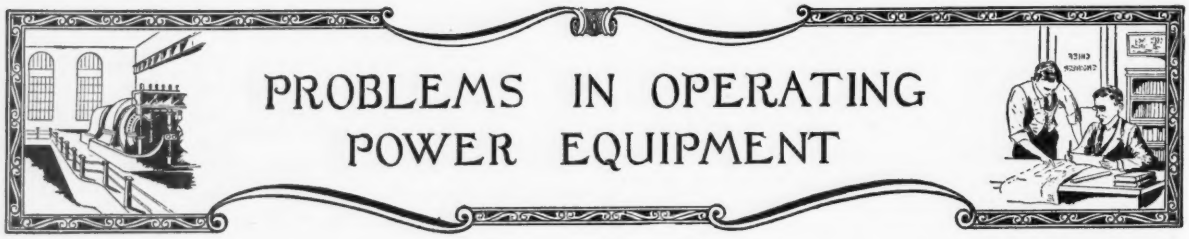
THE GRIP illustrated in the accompanying sketch, which was devised to replace a wood grip when this was split with repeated driving to tighten after persistent



CONSTRUCTION OF HOLDER FOR SOLDERING BIT

loosening, is a simple and durable grip, which does not heat appreciably and, due to the springy clamps, has been found to provide an advantageous addition to the soldering bit. A piece of thin brass tubing, about 1⅜ in. outside diameter and 6 in. long, is cut with the hacksaw at six places, partly across, and these sections bent into the shape indicated. The rod of the copper is driven between these sections, which are elastic enough to clamp it tight. The small area of contact between the rod and the handle accounts for the lack of heating up, as these small connectors do not conduct the heat from the copper into the handle to any appreciable extent.

Washington, D. C. G. A. LUERS.



Maintenance Schedules for Oil Engine Plants

I SHOULD like to secure the comments of any of your readers who have had experience in laying out maintenance schedules for Diesel and semi-Diesel engine plants. What systematic scheme should be employed for checking up on the operating condition of the various details such as pistons, cylinders, air compressors, fuel pumps, governors, cam shafts, valve lever arms, valve settings, etc.? What should be the regular time intervals between inspections of all the details, to secure the best operating results?

Such schedules are often laid out for steam plants but I have not seen much discussion on such work for oil engine plants. As the maintenance cost of oil engine plants has such a definite bearing on the total operating cost, I believe the subject is an important one. If any of your readers can give me information regarding their methods it will be highly appreciated.

Chicago, Ill. R. H.

Design of Electromagnet for Operating Valve

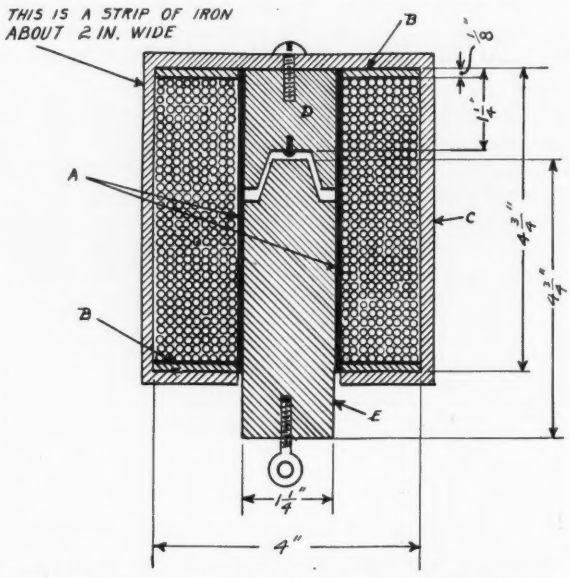
I HAVE a certain valve in my plant which, after tests, I have found requires the exertion of fifty pounds, dead weight, to close it. It is my desire to close this valve electrically by means of a suitable solenoid or magnet of sufficient capacity. The complete travel of the valve is but 3/8 in.

Can you give me information relative to the proper sized hollow core solenoid that would give me this travel and what the proper winding and construction would be, using 110 v., either a.c. or d.c., as the medium? I would prefer a solenoid that is short and broad rather than one which is long and narrow. J. W. S.

A. In designing a lifting electromagnet, there are no simple formulas for the most efficient designs which will give accurate results, and when a design is used which obeys a simple formula, then it may be only 25 or 50 per cent efficient. There is available, however, a wealth of data taken from actually constructed and tested samples which may be used in calculating almost any design. These experimental models are often rated with curves showing the travel of plunger and plotted with pounds pull against watts loss per square inch of outside cylindrical surface. Thus it will be seen that the same electromagnet which, for example, pulls 15 lb. with a continuous duty winding using 0.7 w. per sq. in. may pull 50 lb. with a momentary duty winding employing about 12 w. per sq. in. The pull of a solenoid is limited by its ultimate temperature which in turn depends on the current and the length of time it is in service. Thus a continuous duty electromagnet may employ a current density of perhaps 1000 amp. per sq. in., while the writer has in mind a special magnet with a 1 sec. rating which passes 15 amp. through a No. 36 B. & S. gage wire.

For the problem in question we will assume that small size is desirable and that a momentary duty winding will be satisfactory. This winding should not be in circuit more than 2 min. in every half-hour, and if more than this is required a larger design must be employed.

Figure 1 shows the approximate dimensions of the electromagnet best suited for this pull and length of stroke. It will be noted that the wire is wound on a



DETAILS OF CONSTRUCTION OF MAGNET FOR OPERATING VALVE

brass tube A with brass, iron, micarta or fiber ends, B. This spool is surrounded by a soft iron yoke, C, with an iron stop, D, fitting into the tube. The iron plunger, E, should work freely in this brass tube.

Note the peculiar shape of the plunger and stop ends. This is necessary to get a high pull at the start of the stroke and a more uniform pull over the entire range. Also note that a small copper rivet will prevent "sealing" or sticking of the plunger when it rises and the current is shut off.

From results on samples of this dimension the following pulls may be expected:

PULL IN POUNDS	WATTS PER SQ. IN.	PULL IN POUNDS	WATTS PER SQ. IN.
1-in. gap		½-in. gap	
24	0.07	25	0.07
32	2.8	32	2.8
51	8.0	53	8.0
56	11.8	60	11.2

There may be a wide divergence from these results, however, due to the use of different grades of iron.

Calculations of the winding are also quite complicated if formulas are used, but the easiest way is to make an intelligent guess from experience and work out the problem backwards.

For example, assume that the spool is to be wound with No. 18 B. & S. gage single cotton covered wire, as this sounds reasonable, and then figure out the current and watts of such a winding. The active winding space is about 4½ in. by 1½ in. From a wire table we find that the diameter of a No. 18 wire is 0.045 in. over the insulation. Dividing 4.5 by 0.045 gives 100 wires per layer. In the same manner we find that 1.25 divided by 0.045 gives about 28 layers. This makes a total of about 2800 turns.

The average diameter of each turn is 2¾ in. so that the average length of a turn will be 8.63 in.; and the length of 2800 turns will be 24,164 in., or approximately 2000 ft. No. 18 wire has a resistance of 5.88 ohms per 1000 ft., or a total resistance of about 11.7 ohms. This will take about 10 amp. from a 110-v. circuit and will require a total of about 110 w. to be radiated. The outside surface of the coil will be 3.14×4 in. $\times$ 4.75 in., or about 60 sq. in. Then 110 divided by 60 gives about 18 watts per sq. in.

This is considerably too high, according to our figures, so we may try a No. 20 or a No. 21 wire, figuring out the turns, resistance, current and watts as before. A good plan is to remember that every third increasing size number of a B. & S. gage wire will halve the cross-section and double the resistance. So, roughly, figuring this winding, if we use a No. 21 wire instead of a No. 18 wire, we would double the resistance if the length of wire was the same; but the cross-section is halved, so we can get twice the turns on and consequently twice the length of wire. This again doubles the resistance, thus making it four times the original value. The current would then be one-fourth its previous value, or about 2.5 amp., and the watts would be about 27.5. The watts per square inch would be about 4.6 and this value would give a pull of about 42 lb. This would indicate that size No. 20 wire would be about the correct size.

Summit, N. J. VICTOR H. TODD.

Safety Valves on Superheaters

I HAVE four B. & W. boilers equipped with superheaters. The safety valves on the boilers are set to blow at 200 lb. pressure. For what pressure should the safety valves on the superhaters be set. C. B. F.

A. Ordinarily safety valves on superheaters are set to blow at a pressure somewhat (say ½ to 1 lb.) lower than that at which the valves on the boiler proper are set. The reason for this is that if the steam demand on the unit should drop suddenly to a very small amount or cease altogether, and the safety valves would open, if the valve on the boiler opened first, there would be little if any circulation of steam through the superheater tubes and they would quickly become overheated with possible disastrous results. By allowing the superheater valve to blow first, this danger is eliminated as there is insured a continued circulation through the tubes.

Relation Between Draft and Velocity

IF THE products of combustion in a locomotive pass through the stack with a velocity of 180 mi. per hr., what draft would be indicated on a draft gage at this point? V. N.

A. The relation between the velocity of any fluid, be it water, steam, air or flue gas, and the pressure difference causing this velocity is expressed by the equation

$$V = \sqrt{2\,g\,h}$$

where V is the velocity in feet per second, g is the acceleration due to gravity, 32.2 ft. per sec.², and h is the head in feet of the fluid under consideration. The velocity of 180 mi. per hr. is equal to $5280 \div 3600 \times 180$ or 264 ft. per sec. Substituting these values in the equation given, we have

$$264 = \sqrt{2 \times 32.2 \times h}$$

from which

$$h = (264 \div 8)^2 = 33^2 = 1089 \text{ ft. of air.}$$

As air at the temperature of the flue gases, say 700 deg. F., has a specific volume of about 25.2, the equivalent pressure is $1089 \div 25.2 = 43.2$ lb. per sq. ft., or $43.2 \times 12 \div 62.5 = 8.3$ in. water, which would be the reading of the draft gage.

Exhaust Pipe Size

WE HAVE a 5-in. steam pipe supplying steam at 120-lb. pressure to a simple four-valve engine. How large should the exhaust line be, discharging direct to atmosphere? C. M.

A. The size of steam and exhaust piping on an engine depends on the total steam consumption, the throttle and exhaust pressure, and the allowable velocities. Usually in reciprocating engine practice a velocity of 8000 or 9000 ft. per min. is allowed in the high pressure line and perhaps 12,000 or 15,000 in the exhaust. If it is assumed that the 5-in. line was designed for a velocity of 9000 ft. per min. with steam at 120 lb. gage and if it is also assumed that a desirable exhaust velocity is 15,000 ft. per min., the correct size of exhaust pipe may be found as follows:

The specific volume divided by the allowable velocity is to the cross-sectional area of the high pressure pipe as the specific volume of the exhaust steam divided by the allowable velocity is to the area of the exhaust pipe. From a steam table it is found that the specific volume of steam at 120 lb. gage is 3.33 and at atmospheric pressure, 26.8 cu. ft. per lb. Writing this relation in equation form and substituting the known values, we have

$$3.33 \div 9000 \div 0.7854 \div 5^2 = 26.8 \div 15{,}000 \div 0.7854 \div d^2$$

where d is the diameter of the exhaust pipe.

Solving for d^2, this equation becomes

$$d^2 = (26.8 \times 9000 \times 25) \div (3.33 \times 15{,}000) = 120.7 \text{ sq. in.}$$

Therefore $d = \sqrt{120.7} = 11$ in.

This solution assumes the steam to have the same quality before and after expansion which is of course not the case. If the exhaust is wetter than the high pressure steam the velocity in the exhaust line will be reduced, or if the specified velocity is to be maintained, the sectional area may be less by an amount equal to the ratio of the qualities before and after expansion.

POWER PLANT ENGINEERING

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Selection of Switchboard Equipment

The switchboard has justly been termed the brain of the electrical system. It is the point from which and through which, all control of connected apparatus is effected. Its function is to collect and distribute the generated electric energy and to provide that degree of flexibility necessary to the correct functioning of the system as a whole.

Along with the advance of modern engineering, the switchboard has grown from a crude beginning to an affair of imposing aspect and huge proportions, complex in structure and of attractive appearance. With its glass encased jeweled instruments, its rows of control levers, innumerable signal lenses and protective relays, the modern switchboard carries with it an atmosphere of quiet dignity commensurable with its importance. It is the most vital link in the chain of events extending from the coal pile to the point of power consumption.

Because of its importance, it is essential that careful consideration be given to the proper selection of switchboard equipment for any plant. Modern electrical engineering, however, with its diversified applications, has brought about an almost endless variety of sizes and types of switchboard equipment, and unless an engineer is familiar with development in the field, he is apt to be confused, when it becomes necessary to put in a new board. Many points have to be considered, such as capacity, type of service, voltage, method of control, safety location, etc., any of which may influence the design materially. The question of interconnection with the public service company, if it is an industrial plant, will also introduce complications, the proper solution of which necessitates more or less specialized knowledge.

Attention is therefore directed to the article on selection of switchboard equipment, by S. W. Manger, which appears in this issue. Mr. Manger, by virtue of his experience in switchboard work at the General Electric Co., has been able to treat this subject from a thoroughly practical viewpoint, and his article will be found well worth while to anybody interested in the selection of switchgear.

Accident Prevention

More now than at any other period in its history the electrical industry evinces appreciation of the possibilities in the prevention of accidents. As a general rule, accident prevention in this industry has passed the experimental stage and it now is an integral factor in every operation. The degree to which precautionary measures against the occurrence of accidents are taken has now become in a measure a criterion as to the character of the management, efficiency of operation and adequacy of service. It means more than prevention of waste, or economical production, or self preservation; it means a moral duty accomplished and service rendered.

To one having the interest of the human race and commendable progress at heart, it is gratifying to know that so important a factor in our national life as the public utility has materially assisted in the solution of the safety problem. The goal has not yet been reached nor probably will it ever be, but much has been done and much credit is to be accorded. The attitude of the industry is still an inquiring one but it

is no longer "Why" but "How." Missionary efforts are less necessary; the specialist on the subject does not now have to spend time convincing his patient; rather his work now lies in the prescription of remedies.

In its report presented at the recent meeting of the National Electric Light Association, the committee on accident prevention states that during the past year it has not had time to evolve hypothetical problems on safety work but on the contrary has experienced difficulty in affording proper consideration to specific demands for recommendations as to safe conditions and safe methods solicited by operators. This report deals then with everyday operating matters of real and constructive value and should be of interest to anyone concerned with the prevention of accidents—all of us.

Good engineering practice now must make provision for safety in operation. In the design and arrangement of machines this factor must be taken into consideration so that in the operation of the plant the human element will have less influence. To this end the safety engineer and the designing engineer should consolidate their efforts in the development of new apparatus.

Oil Engines as a Competitor of the House Turbine

While the oil engine has been gradually making its entry into the power plant field as an efficient and reliable type of prime mover, the use of such units has been limited to stations where the load could be handled by several units of about 3000 or 4000 hp. each as the maximum rating. Apparently no serious thought has been given to the possible use of such units as a source of power for driving electrified auxiliaries.

It was, therefore, with some interest that engineers at the recent National Electric Light Association convention listened to the suggestion of Charles H. Merz, consulting engineer of London, that internal combustion engines might offer a possible solution for the problem of providing a separate power supply for station auxiliaries.

Every year sees the increasing use of motor driven auxiliaries and the question that comes up during the design of each new station is how to provide a current supply for these motors which can be used for starting up the station or which will not be affected by a general service interruption. The house turbo-generator has gained headway for such service since its use fitted into the station heat balance scheme. Now, however, with the use of bleeder steam for feed heating the house turbine is not of such importance in the heat balance arrangement.

Two arrangements have been worked out of late which tend to place the production of auxiliary power on a more efficient basis. One of these is to use the house turbine to drive a synchronous condenser which floats in parallel with the bus supplying the auxiliaries. In cases of an interruption of current the condenser becomes a generator and automatically picks up the load. With this arrangement the value of the steam used for driving the turbine is partly compensated for by the improved station power factor. The other scheme for supplying current to the auxiliaries is through the use of an auxiliary generator direct connected to the main turbine, with entirely separate bus and switching equipment. In this way reasonable reliability of supply is assured for a station containing more than one prime mover.

There are certain objections to all of these methods and hence Mr. Merz's suggestion regarding the use of internal combustion engines for such service is interesting. Where high pressures are gone into for securing the utmost efficiency at the main units, it seems rather extravagant to throw a part of this gain away through the use of the less efficient house turbine. Since the oil engine has a high thermal efficiency the installation of such engines for auxiliary power offers a possible solution.

It would appear particularly feasible for such stations as are using fuel oil under boilers since the problem of obtaining an oil supply would be eliminated.

While the internal combustion engine is not yet a competitor of the house turbine the time may yet come when it will be so considered.

Pulling Together

"Pulling together" is the name of an interesting little book by John T. Broderick dealing with human relations in industry. It was a reading of this book that suggested this editorial. In his book, Mr. Broderick makes no reference to power plants nor to any phase of engineering in particular, but the things he says in regard to the value of co-operation apply to power plants just as much as they do to any other line of human endeavor. The success of any venture in which more than a single individual is concerned depends largely upon the spirit in which the component parts of the organization co-operate, or as Mr. Broderick expresses it, in the way they pull together.

To secure the best sort of co-operation among any group of individuals it is necessary to obtain their confidence. An excellent method of establishing this confidence and one which has worked out successfully in practice, is in the holding of weekly meetings where all employes of a certain department get together and discuss their work. Suggestions are accepted and if anyone has a grievance he is encouraged to present it.

Such meetings have gone a long way in smoothing out slight difficulties due to personal feeling and in establishing a closer fraternal spirit in the organization as a whole. By talking things over in a friendly way, many petty troubles can be eliminated. Discussion at these meetings will show each man his place in the organization and his relation to the "other fellow" and thus introduce in all the proper spirit for pulling together. If you, as chief engineer, or superintendent, or whatever position of authority you hold, have had difficulty in meeting your human engineering problems, it will be well worth your while to consider the weekly meeting plan. At any rate, it will do no harm to try it out.

To FIGURE the mean temperature difference between the steam entering a condenser and the cooling water, use the formula $\text{M. T. D.} = T_s - \frac{T_1 + T_2}{2}$, in which T_s equals the temperature corresponding to the vacuum in the condenser, T_1 equals the temperature of the incoming water and T_2 equals the temperature of the water leaving the condenser.

POWER PLANT ENGINEERING DEVELOPMENTS AND NEWS

Features of a New Primm Semi-Diesel Engine

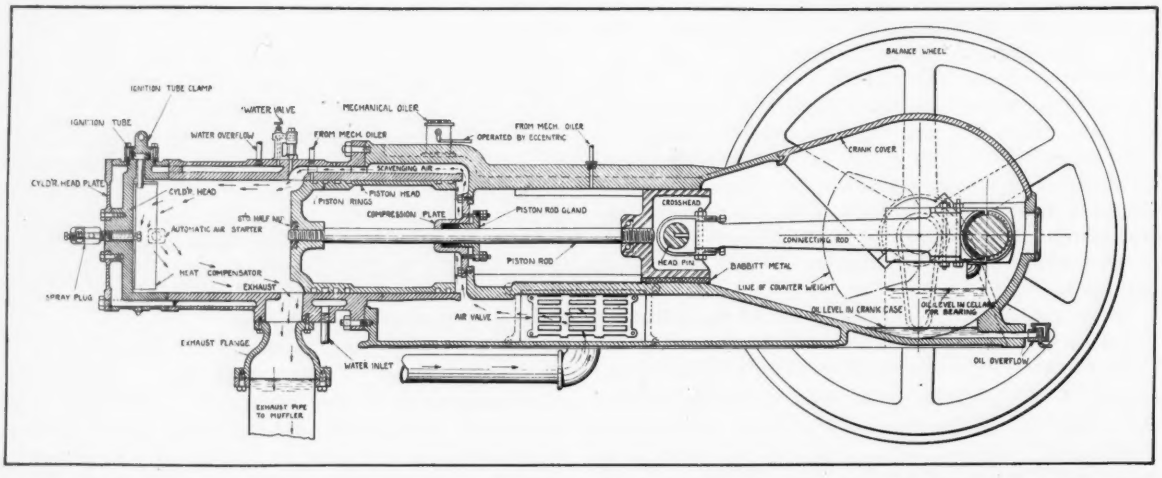
WHILE the latest type of Primm oil engines manufactured by the Power Mfg. Co., of Marion, Ohio, is along the same general lines as previous engines built by this organization, there are a number of new features which have been incorporated. This engine is of the horizontal, crosshead type and operates on the two-cycle principle, using the front end of the cylinder and an air space in the bed plate as a compression chamber for the scavenging air.

Air ports in the cylinder have a peculiar shape which directs the scavenging air toward the combustion chamber and offer the minimum resistance to the passage of the air through the ports. The air valve is a series of light steel strips, this arrangement offering a large air opening with a small valve lift and a consequent low vacuum on the suction stroke.

For the spray plug a needle type valve is used, which is opened by pressure built up by the injection pump and closed by a compression spring when the pressure has been released. Oil is sprayed into the cylinder at right angles to the axis of the plug through a series of small holes in the wheel spray. This spray contains a seat for the needle valve.

One of the unique features of the engine is the device which is called the heat compensator. This device serves two purposes: To retain some of the heat of combustion to aid the combustion on the next stroke and to control the heat in the combustion chamber by contracting and expanding, thus bringing it farther away from or closer to the water cooled walls of the cylinder head. The valve controlling the injection water is automatically controlled by the governor which varies the amount of water injected in direct proportion to the load on the engine.

As will be noted from the drawing, the crosshead used is a solid type with a clamping projection to secure the piston rod against turning. The bottom bearing surface is babbited, which gives a good bearing and affords a means for taking up the wear. A combinationof splash and force feed lubrication has been provided owing to the rigorous service to which the engines are subjected in certain fields of operation, especially in the rice fields where they are used as power units for irrigation pumps. The flyball governor is used which varies the amount of fuel injected by varying the length of the pump stroke, the pump being operated by an eccentric on the main crankshaft.



AIR PORTS IN THE CYLINDER ARE SHAPED TO DIRECT THE SCAVENGING AIR TOWARDS THE COMBUSTION CHAMBER

This engine is built in sizes from 20 to 150 hp. in single cylinders, and from 200 to 300 hp. in double cylinders, and is built in two types: one for commercial uses and one for electrical and kindred work. A fuel consumption guarantee of 0.6 lb. per b.hp.-hr. is made by the company, but brake tests made on the blocks at the factory have shown actual results as low as 0.51 lb. per b.hp.-hr.

Injection water is controlled by a valve which is automatically operated as to opening by the governor and the amount of water injected is in direct proportion to the load on the engine.

Differential Relay Protects Transmission Lines

IN CASES where two or more transmission lines are in parallel, means must be provided for disconnecting a defective line without interrupting the power service in the remaining lines. Various methods of accomplishing this are in common use; but practically all of them involve either the use of special apparatus, such as split conductor cables, or the necessity of potential connections. For the purpose of giving balanced protection of transmission lines, the Westinghouse Electric and Manufacturing Co. has developed a current relay that requires no more apparatus or connections than are ordinarily needed for the simple overload (short circuit) protection of transmission lines.

This relay, which is known as the type CD, works on the induction principle and operates on current alone,

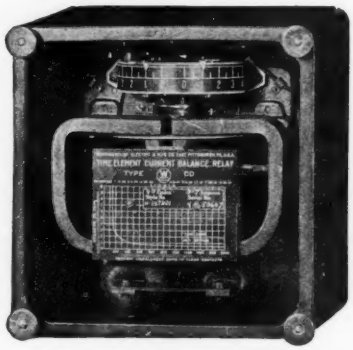


FIG. 1. NEW TYPE WESTINGHOUSE DIFFERENTIAL RELAY

so that no source of potential is required. This is of advantage, particularly on high voltage lines where the cost of potential transformers is considerable. Also there are no phase relations to be considered in connecting up this relay. The relay has two overload elements acting upon a common disc through a common magnetic circuit. Each element is connected separately to its own current transformer in corresponding phases of the two balanced lines. The two elements are electrically opposed, and under conditions of balanced line loads the fluxes in the magnetic circuit of the relay are equal and opposite, giving a resultant zero torque on the relay disk. Under these conditions, the disk which carries the moving contact is held in a mid-position by the control springs. These springs are initially restrained in the zero position, which prevents the disk from making any movement until a predetermined current unbalance exists between the two lines. Under the proper condition of current unbalance the disk can rotate 80 deg. in either direction from zero and make contact on either side. Thus the moving contact acts as a single-pole, double-throw switch in the trip circuits of the circuit breakers of the two unbalanced lines, and will trip out the circuit breaker on the line carrying the heavier load. This action is the same regardless of the relative directions of the currents in the two lines.

For all load values of line current in the lower loaded line the differential current which is required to trip the relay is practically the same. If, however, one line of the balanced pair is open, the current in the relay necessary to cause it to trip out the remaining line is approximately twice the differential current setting. This automatic doubling of the current setting with one line open is due to the fact that half of the operating coil of the relay is then no longer active, as it receives no current from the dead current transformer in the open line. This is a very desirable feature, as it gives automatic protection to the service if one line is accidentally opened. Thus if each line were carrying 100 per cent load, with the relay set to operate at a differential current of 150 per cent of the load of one line, and an accidental switching operation occurred to open one end of one of the

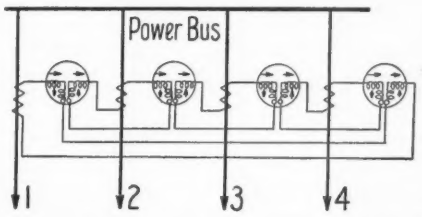


FIG. 2. SCHEMATIC DIAGRAM OF CONNECTIONS, SHOWING THE METHOD OF APPLYING THE RELAY TO PROTECTION OF TRANSMISSION LINES. RELAY APPLIED TO FOUR PARALLEL FEEDERS

lines, the remaining line would carry the double load. The relay on the opposite end would not, however, close contacts due to the unbalanced load current, for, although the one line would then be carrying 200 per cent load, the relay setting would have been automatically increased to 300 per cent, leaving an ample margin of safety. When the accidentally opened switch was closed, the balanced protection would be again restored. This feature also makes it unnecessary to render the trip circuit of the differential relay non-automatic while the parallel lines are being connected to the busses at both ends; for it can be seen that after both ends of No. 1 line, and one end of No. 2 lines have been closed, the

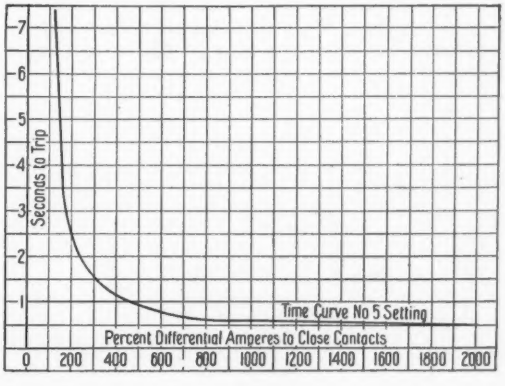


FIG. 3. TYPICAL LOAD-TIME CURVE OF CD CURRENT BALANCE RELAY

same condition will exist as described above when one end of one line is accidentally opened.

It will be noted that when one of the lines is opened the differential relay is then automatically converted into an overload relay, with a tripping current setting of twice the differential setting, and with the disk tending to rotate in such a direction as to trip out the loaded line.

This means that the remaining line may then be considered as provided with overload protection without the use of additional overload relays, if so desired. It should be remembered, however, that the current balance relay is set for a short time operation, which is not usually desirable for overload protection. The condition of through short-circuits, i. e., short-circuits on other sections of the system, should also be considered, as this condition usually requires selective settings of the overload relays in series on the system. For this reason, it is customary to use overload relays in series with the current balance relays to give selective overload protection to the remaining line after one of the balanced lines has been disconnected.

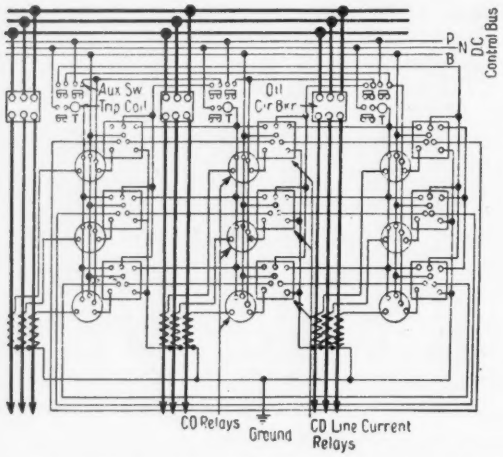
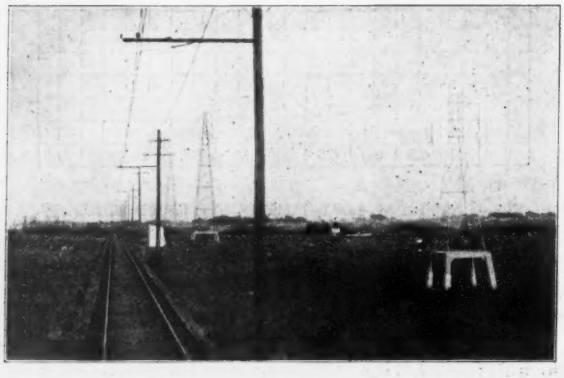


FIG. 4. COMPLETE CONNECTIONS FOR PROTECTION OF THREE OR MORE PARALLEL LINES

This current balance relay can be used at the transmitting ends of any number of parallel feeders. It can be used at the receiving ends of any number of parallel lines in a system having a source of power at both ends, or at the receiving ends of three or more parallel lines in a radial system. In brief, it can be applied at any point in a system where, in case of trouble on one parallel line, this line will receive more current than the other line of the pair.

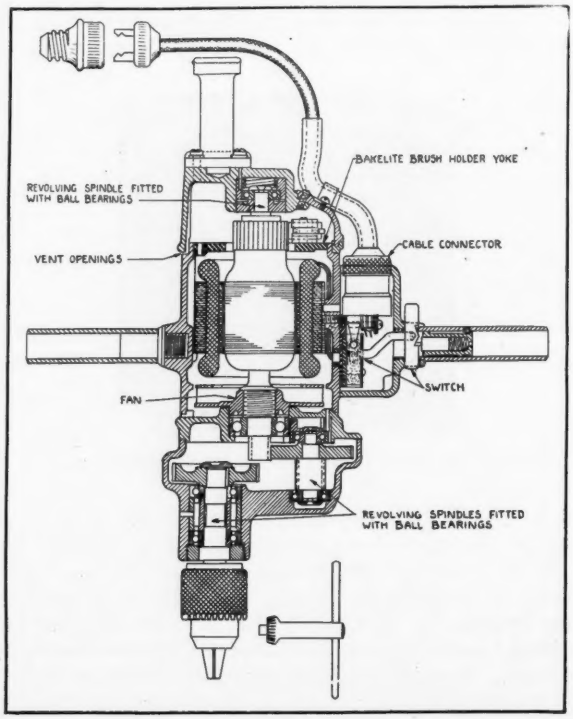
Transmission Towers on Concrete Legs



Where the line passes through the river districts, the steel towers of a California power company are supported on concrete legs. This is done to protect them from the water and from being struck by floating logs, etc.

New Universal Motor Drill Brought Out

SEVERAL features of interest are incorporated in the new "Hisey Super" universal motor drill which has recently been placed on the market by the Hisey Wolf Machine Co., of Cincinnati, Ohio. As will be noted from the accompanying sectional view, the motor is cooled by forced ventilation. At the handle end of the machine vent openings are placed so that all the cool incoming air must pass over the commutator and brushes before being drawn through the motor and expelled. The location of the fans is such that it prevents lubricating grease in the gear head from working into the motor parts.



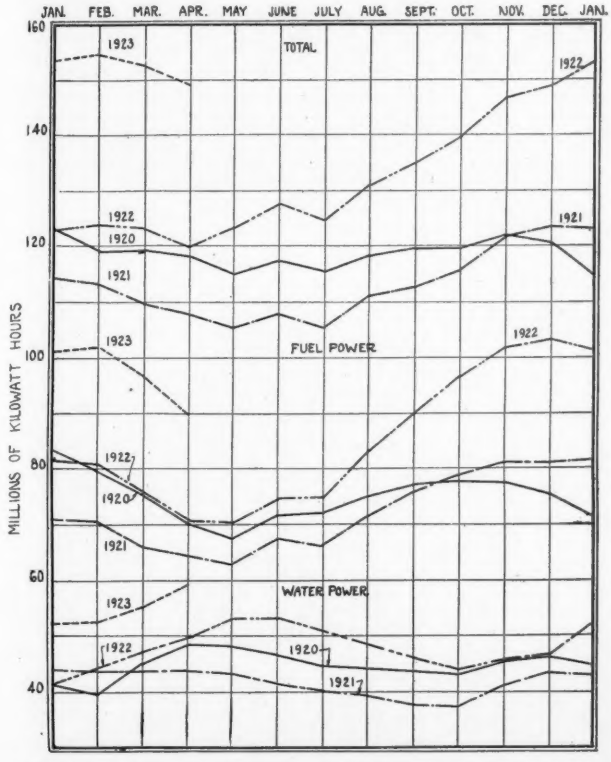
PORTABLE DRILL USES FORCED VENTILATION

All spindles are fitted with ball bearings securely fastened. To eliminate strains so common with permanently fixed bearings, a spring tension is provided. This feature automatically permits expansion and contraction of the shafts without distortion. Another feature is a quick cable connector which permits cable repairs and renewals without dismantling the machine which is said to eliminate the loss of time and inconvenience common with some types of electric drills. The brush holder yoke is made of bakelite which is not affected by oil or atmospheric conditions. This yoke is also adjustable and the motor brushes can be shifted from outside without dismantling the machine.

IF COAL has a tendency to cake, it will be necessary to slice frequently. Do not lift the ash into the hot zone and thus form clinker; simply run the slice bar under the fuel fed and hoist slightly with a side motion to open up air holes.

Seasonal Decrease Shown in Production of Electricity

AVERAGE daily production of electricity by public utility power plants in the United States for the month of April, 1923, was 149,300,000 kw.-hr. This was about 2 per cent less than the average daily output in March of this year, and 3 per cent less than the record breaking output of February, 1923. The decrease in production from February to April was unquestionably due



AVERAGE DAILY PRODUCTION OF ELECTRICITY BY PUBLIC UTILITY PLANTS IN UNITED STATES

to the seasonal decrease in the demand for electricity. An examination of the curves for the years 1920, 1921 and 1922 shows that this same decrease was in evidence during the corresponding periods. The progressive increase of industrial activity for 1923 was not sufficient to overcome the season decrease in rate of consumption.

For the first four months of 1923 the average daily production of electricity was as follows:

January	153,300,000 kw.-hr.
February	154,400,000 kw.-hr.
March	152,500,000 kw.-hr.
April	149,300,000 kw.-hr.

whereas the proportion produced by water power was;

January	34.0 per cent
February	33.9 per cent
March	36.3 per cent
April	39.8 per cent

The increase of production by water power is due not alone to increased capacity of hydro-electric plants but also to the increased amount of water available for power purposes at this time of the year.

Returns received from 3500 power plants constitute the information upon which this report is based. These plants each produce 10,000 kw.-hr. or more per month and are engaged in public service, including central stations, electric railways, and certain other plants that contribute to the public supply. The total capacity of these plants was about 16,150,000 kw. in March.

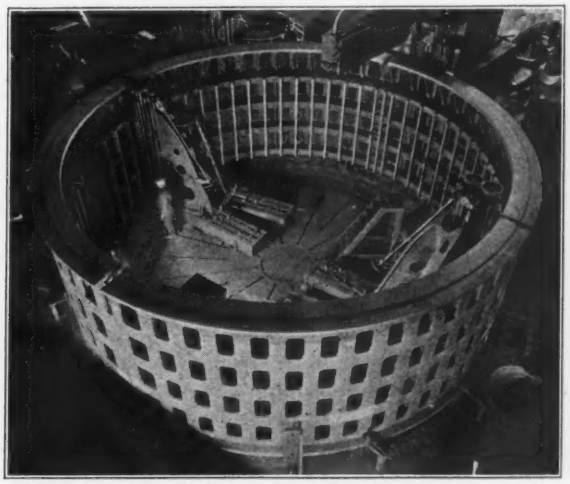
Compilation of this data was made and reported by the Department of the Interior, Geological Survey.

Kentucky Company to Build New Station

WORK WILL start soon on the construction of a new modern power station for the Paducah Electric Co., which furnishes electric light and power, gas and street railway service to Paducah, Ky. The first bay of the new station will be built adjoining the present station at Second and Jefferson Streets and the design will allow for future expansion by adding more bays, up to 15,000 kw. or more. The new building will be 104 ft. by 25 ft., of steel frame construction, with brick walls and stone trimmings. A 2500-kw. Westinghouse turbo-generator will be installed and a 612 hp. Stirling boiler with chain grate stokers and with the necessary auxiliary equipment. Complete coal handling equipment will be provided for conveying the coal from the cars through a crusher and overhead bunker to the new stoker and to the floor of the present boiler room, also equipment to facilitate the handling of coal to and from the yard storage.

Stone & Webster, Inc., of Boston, Mass., will handle the design and construction. The estimated cost is $370,000.

World's Largest Waterwheel Generator

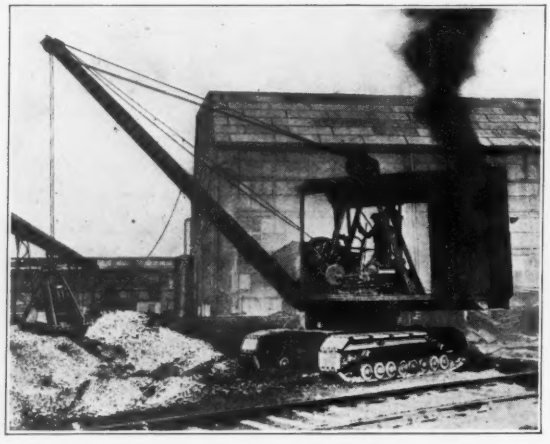


Machining the stator of a 65,000-kv.a. generator in the shops of the General Electric Co., Schenectady. This unit has been ordered by the Niagara Falls Power Co. for its No. 3 power station and is the first of two units of the same size being built by the General Electric Co. Each generator will weigh 700 T. and will be 26 ft. high and 35 ft in diameter. Both as to size and capacity they are the largest in the world. They will be driven by 70,000 hp. hydraulic turbines made by the I. P. Morris Department of William Cramp Sons Shipbuilding and Engine Co., Philadelphia.

Crawler Crane Is Convertible

THROUGH the use of various attachments the McMyler Interstate Co. of Cleveland, Ohio, has recently brought out a crawler crane which may be used for different classes of service. It is possible to equip the crane as follows: with a boom and clam shell or orange peel buckets; with steam shovel attachment; to operate drag line buckets; for pile driver work, to operate a back filling attachment; or to use as a skimmer scoop. This is the smallest unit yet developed by this organization, having a pull of 6000 lb. for single line bucket work with a hoisting speed of 200 ft. per min. The maximum single line pull is 10,000 lb. With a 30 ft. boom at a 10-ft. radius the crane will handle a 20,000 lb. load.

Various operations of the crane are actuated by a 35-hp. double cylinder, non-reversing steam engine.



CRANE EQUIPPED WITH BOOM AND ORANGE PEEL BUCKET FOR HANDLING COAL AND OTHER SIMILAR MATERIALS

Link motions and reversing valves are eliminated through the use of right and left hand clutches for raising and lowering the boom, for sluing and for propelling.

Shifts from one direction to the other, in operating the hoists or while sluing, may be made with rapidity since the engines are constantly running in a single direction and no time is lost in stopping and then accelerating in the opposite direction. A single lever controls each pair of clutches so that each operation in either direction is controlled by one lever only. The maximum loads which the crane is designed to carry are handled with the engine running at normal speeds.

Sluing is accomplished through the vertical sluing shaft which extends through the bed plate and engages its pinion with the circular sluing rack on the traveling base. Power is applied to this sluing shaft through right and left hand friction clutches of the asbestos lined cone cup type.

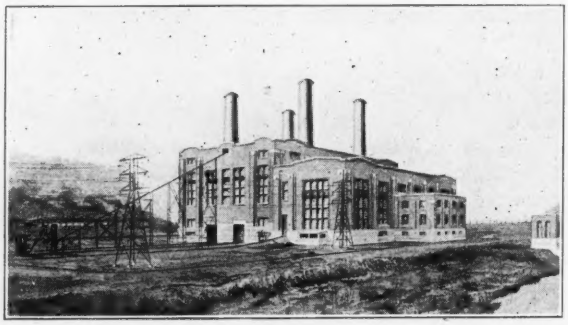
Each crawler tread is an endless chain or belt made up of high carbon steel castings which travel over high carbon sprocket wheels at each end of a rigid frame. The castings forming the tread are linked together with hardened steel pins designed to withstand excessive wear and vibration. Each sprocket wheel is supported between two bronze bushed bearings. The drive to the crawlers from the propelling mechanism is through heavy gears, on the driving sprocket wheel shaft, which engage with the driving pinions of the traveling mechanism.

Power for traveling is taken from the engine through right and left hand jaw clutches and gears through the bed plate to the driving sprocket wheels on the crawlers. The entire traveling mechanism is unusually simple and rugged. An outstanding feature is that all chains and differential gears have been eliminated.

When traveling a straight course, the two jaw clutches engaging the driving crawler sprocket wheels are held in engagement by means of a compression spring. The crane is steered by temporarily withdrawing the power from the crawler on the side toward which the machine is to be directed. After the crane has swung into the desired position the power is again applied equally to both crawlers.

This shifting of the power from both crawlers to either one alone is accomplished through jaw clutches that engage and disengage the gears on the sprocket wheel shaft. These operations are controlled entirely by the operator on the crane without the assistance of a man on the ground. The operator throws a hand lever which causes an asbestos lined band to grip a wheel pivoted to the under side of the turn-table and connected by links to the jaw clutches. By sluing the crane in the desired direction of travel, this wheel is turned disengaging the proper jaw clutch and causing the crane to swing.

Grand Tower Station as It Will Appear When Completed



Construction work on the Grand Tower Station at Grand Tower, Ill., has reached the stage where the foundations are under way. Condenser wells, which are 60 ft. in diameter and 40 ft. deep, have been completed. This station is being erected by the Middle West Power Co., a subsidiary of the Middle West Utilities Co. Although the present building is constructed to house two 25,000-kw. units only one unit will be installed at the present time. The ultimate capacity will be made up of four of these units. Turbines will be of the new Westinghouse single cylinder design; 350 lb. at the throttle and 700 deg. F. Babcock & Wilcox boilers of the Waukegan type will be used and Worthington will furnish the vertical two-pass condensers. Boilers will be equipped with Illinois forced draft chain grate stokers. Sargent & Lundy, Inc., are the engineers.

MARCH PRODUCTION of gasoline amounted to 630,701,000 gal. and stocks at the end of the month to 1,259,209,000 gal., as compared with 854,232,000 gal. on hand at the end of March last year.

New Hydro-Electric Plant for Southern California

BUILDING the largest hydro-electric generating powerhouse in the West by the Southern California Edison Co. of Los Angeles, in the grand canyon of the San Joaquin River in the High Sierra Mountains is well under way. This powerhouse will be the fourth of the chain of Edison company powerhouses on its Big Creek-San Joaquin River project, and the first to be constructed on the main channel of the San Joaquin River, far down the canyon. It will have a capacity of 100,000 hp. and will receive its water supply by diverting the river through a tunnel nearly 6 mi. long and 21 ft. in diameter, now nearing completion, which is a part of 86 mi. of tunnel system contemplated in this development project.

It is expected that the first 33,000 hp. generating unit will be placed in operation about Aug. 1, and will be followed by the second unit about Sept. 1. It is expected that the entire plant will be completed and the power placed on the lines about Oct. 1. This power will be transmitted for distribution over the first commercially operated transmission in the world, at a distance of 240 mi.

Completion of this powerhouse will be the consummation of the fourth step in the Southern California Edison Co.'s Big Creek-San Joaquin River project, which contemplates developing 1,407,000 hp. of electricity from the water courses of the High Sierra Mountains in central California at a cost of $375,000,000, or about $15,000,000 more than the Panama Canal. The cost of construction of this powerhouse is provided for in the annual budget of the Southern California Edison Co., which appropriates $26,000,000 for hydro-electric development and apparatus and transmission and distribution lines during the year 1923.

With the completion of the great Florence Lake tunnel, over 13 mi. in length, the longest in the West, the great watersheds which lie between the Kaiser Range and the Minaret Range in the High Sierras, having an area about the size of the Hawaiian Islands, will be tapped and their flow from the melting snows will reach the generators of this new plant at a fall from Mt. Hilgard, the highest summit, of about 11,000 ft. or more than 2 mi. of perpendicular drop. After they have passed through the turbines of this plant, they will return undiminished into the San Joaquin River in an even flow to irrigate the valley beneath, flood damage and waste of water being completely eliminated.

News Notes

THE HAGAN CORPORATION, of Pittsburgh, Pa., has removed to its new offices, 1301 Chamber of Commerce Building.

AT A STOCKHOLDERS' meeting held May 28, the name of the Electric Steel Co., Chicago, was changed to Nugent Steel Casting Company. There will be no change of management, ownership, or personnel, however.

HARLAN W. BIRD, formerly with the Roto Co. as sales engineer in Illinois and Indiana, is now connected with the Peoples Gas Light and Coke Co., of Chicago, in the Industrial Department.

R. L. BARKER & Co., of Chicago, has been appointed the exclusive representatives in Indiana, Illinois, Wisconsin and Iowa, for the Hisey Wolf Machine Company of Cincinnati, manufacturers of portable electric drills, screw drivers, grinders and buffers.

F. H. WORTHINGTON, associated with the Jacksonville (Fla.) office of the General Electric Company, has been appointed local manager of the Jacksonville office to succeed G. C. Henry, who recently resigned. The appointment was announced by E. H. Ginn, district manager Atlanta and is effective July 1.

C. H. ROESSNER has been appointed district sales manager for the Foxboro Co., Inc., Foxboro, Mass. He will have his central offices at 1510 Monadnock Bldg., Chicago, Ill. Mr. A. F. Mundy, formerly of the Chicago office, will represent the company in southern California, with offices at Pacific Finance Bldg., Los Angeles, Cal.

MCCLAVE-BROOKS Co., Scranton, Pa., announce the opening of a branch office in Cleveland, O., under the management of Mr. J. W. Whitmore, formerly of the Scranton office.

It is also announced that the Dennis Engineering Co., 243 High St., Columbus, O., has been appointed to represent the McClave-Brooks Company in western-central and southwestern Ohio. Their territory will include 17 counties, as well as the city of Columbus.

AT THE SPRING MEETING of the American Society of Mechanical Engineers in Montreal, May 28-31, the Nominating Committee presented the following nominees for the offices of the Society for next year. Election by ballot will be held in the fall:

President, Fred R. Low, New York City. Vice-Presidents, George I. Rockwood, Worcester, Mass; M. L. Cooke, Philadelphia, Pa.; W. J. Sando, Milwaukee, Wis. Managers, E. O. Eastwood, Seattle, Wash; F. A. Scott, Cleveland, Ohio; E. R. Fish, St. Louis, Mo. Treasurer, W. H. Willey, New York City. Delegates to the American Engineer Council, Dexter S. Kimball, Ithaca, N. Y.; William Schwanhausser, New York, N. Y.; S. W. Stratton, Cambridge, Mass.; P. F. Walker, Lawrence, Kan.; F. K. Copeland, Chicago, Ill.; J. T. Faig, Cincinnati, Ohio; R. E. Flanders, Springfield, Vt.; C. C. Thomas, Los Angeles, Calif.; W. B. Powell, Buffalo, N. Y.

UEHLING INSTRUMENT Co., Paterson, N. J., manufacturers of CO_2 recorders and draft and vacuum gauges, have just made two new agency appointments, namely Amsler-Morton Co., Fulton Building, Pittsburgh, Pa., for Western Pennsylvania and Mr. John A. MacDowell, 2039 Railway Exchange Building, St. Louis, Mo., for Eastern Missouri and Southern Illinois. Mr. H. R. N. Johnson, who formerly represented the Uehling Instrument Company in Minnesota and the Dakotas, has joined the W. P. Nevins Company, 120 South Ninth Street, Minneapolis, Minn., which company is now the official Uehling representative in the territory mentioned.

A SEPARATE company to be known as "The Darcoid Co., Inc.," has been formed to take over the manufacture and distribution of the packings, mechanical rubber goods, and miscellaneous asbestos and rubber products of the Dominion Asbestos & Rubber Corporation. The

Dominion Asbestos & Rubber Corporation will confine its activities to the manufacture and distribution of Dominion brake lining and the new Dominion shock absorber. Wm. H. Meek, president of the Dominion Asbestos & Rubber Corporation, is president and treasurer of The Darcoid Company. Wm. F. McClean, formerly of the Gutta Percha & Rubber Mfg. Co., is vice-president, and M. Hueger, formerly of the Dominion Asbestos & Rubber Corporation, is secretary.

THE LEVEL Fuel Bed Detroit Multiple Retort Underfeed Stoker is illustrated and described in detail in a new bulletin, "Built on Advanced Engineering Principles," just published by the Detroit Underfeed Stoker Co. Among other subjects it covers the practical application of well developed principles in the science of combustion in the design and construction of a high duty machine to meet modern requirements for heavy overloads and severe service with large bodies. The bulletin contains many illustrations showing various systems of ash disposal possible with an underfeed stoker.

AT THE thirty-fifth annual convention of the American Boiler Manufacturers Association at Hot Springs, Va., during the week of June 4, the following officers were elected for the ensuing year: president, E. R. Fish of the Heine Boiler Co.; vice-president, E. C. Fisher of the Wickes Boiler Co.; secretary and treasurer, H. N. Covell of the Lidgerwood Manufacturing Co. The new executive committee will consist of George W. Bach, of the Union Iron Works, Erie, Pa.; G. S. Barnum, of the Bigelow Co., New Haven, Conn.; F. G. Cox, of the Edge Moor Iron Co., Edge Moor, Del.; W. C. Connelly, of the D. Connelly Boiler Co., Cleveland, Ohio; W. A. Drake, of the Brownell Co., Dayton, Ohio; A. R. Goldie, of the Goldie-McCulloch Co., Galt, Ont., Canada; J. F. Johnson; M. F. Moore, of the Kewanee Boiler Works, Kewanee, Ill.; and A. G. Pratt, of the Babcock & Wilcox Co., New York.

When the Stoker Manufacturers Association held its annual meeting at the Lake Placid Club, Essex County, New York, on May 29 to 31 the following executive committee for the ensuing year was elected: president, J. C. Worker; vice-president, J. V. Santry; treasurer, R. B. Mildon, and F. H. Daniels and W. H. Rea.

Books and Catalogs

PRACTICAL HEAT, Terrell Croft, editor; 695 pages, 5½ by 8 in., 628 illustrations, cloth; New York, 1923.

Practical Heat is a semi-popular exposition of some highly technical thermodynamic principles and relations; it is well written, profusely illustrated and easily read and understood by anyone having only the most elemental knowledge of mathematics. The text embraces a discussion of the fundamental principles of heat; gas and vapor cycles; fuels; combustion; power plants; internal combustion engines; heating of buildings; and refrigeration.

Simplicity seems to have been the main consideration in the preparation of this text. Fundamental principles underlying thermodynamic phenomena are simply established and well illustrated with descriptive expositions or with worked out arithmetical examples. At the end of each of the main divisions problems are presented and questions asked which if properly answered insure a knowledge of the contents of that division. Detailed solutions are given in an appendix so that answers may be checked back for correctness.

METALS AND THEIR ALLOYS by Charles Vickers; 767 pages, size 6¼ by 9¼ in., 108 illustrations, cloth; New York, 1923.

This volume covers the preparation and use of alloys of every description, and describes their physical and chemical properties, and their various applications in the arts and industries. The author is a practical foundryman of considerable experience in the melting, alloying and casting of metals, and is a contributor to the technical press.

While the book is a thoroughly practical work, and the information and data presented in a form easily understood by the owner, manager or worker in the shop, it may also serve as a reference for the engineer, chemist, metallurgist or trained technical man, who must select alloys possessing properties that meet the requirements of his work.

Chapters on the casting of copper, the making of manganese bronze, aluminum bronze, aluminum alloys, red brass, yellow brass, steam metals and nickel alloys are well supplied with formulas together with the physical properties of the alloys and their casting peculiaries. The formulas are presented in a form easily grasped, and are thus accessible for the untrained man.

HOLOPHANE GLASS CO., INC., 342 Madison Ave., New York, N. Y., has issued a new publication, entitled "Holophane Datalog"—Commercial Edition. This is a 38-page ilustrated booklet, the first 15 pages of which are devoted to illuminating engineering data and includes utilization coefficients for all types of Holophane luminaires and reflectors worked out for various size rooms with various wall and ceiling reflection factors. The remainder of the booklet is devoted to description and data on the more popular Holophane luminaires and reflectors such as are used for window lighting, school lighting, office lighting, factory lighting, yard lighting and reflectors for special uses.

LEAFLET No. 2390A issued by the Westinghouse Electric & Mfg. Co. describes the type E engine driven alternating current generators. Construction of these generators from 50 to 3000 kv.a. is illustrated and described. These generators are applicable to all prime movers being suitable for direct connections to steam, gas and oil engines of slow speeds. The Westinghouse Co. has also issued leaflet 3477B which describes a hot spot indicator for transformers. The device is illustrated with photographs and wiring diagrams showing how the indicator functions and how it is located in the transformer.

MODERN FURNACE building is the title of a 52-page booklet recently issued by the Jointless Fire Brick Co., 1136 Clay St., Chicago. This booklet tells the story of the building of monolythic furnace linings and shows how boiler furnaces, circular furnaces, pit type furnaces and other furnaces may be lined with this jointless furnace lining. Illustrations are also presented showing how forms for special shapes like front door arches are made. There is also a chapter on the making of baffles of plastic linings.